Recreational Fisheries in Biscayne National Park, Florida, 1976–1991

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Introduction

Biscayne National Park (BNP) is located in southeastern Florida just south of Miami (Fig. 1). It has a variety of subtropical marine habitats, including the most northerly coral reefs of the continental United States (Hoffmeister, 1974; Jaap, 1984). Since 1976, recreational creel surveys of anglers were conducted for BNP and surrounding waters. Survey objectives were to establish and maintain baseline recreational fisheries information for long-term resource monitoring, provide estimates of recreational harvest and fishing effort, and detect changes in harvest composition and fishery trends.

In previous studies, Tilmant et al. (1979) did not detect significant ecological impacts from anchoring or fishing activities while conducting fishery-independent underwater monitoring of the resources at selected coral patch reefs in BNP. Tilmant (1981) found no evidence of long-term declines in catch rates of frequently harvested species between 1976 and 1979, but he noted that catches of groupers (*Epinephelus* and *Mycteroperca* spp.) had declined during 1979. Tilmant (1981) concluded that size classes of harvested fishes had remained stable and that the levels of recreational consumption between 1976 and 1979 were not depleting BNP resources. Tilmant and Stone[1] estimated average annual recreational landings between 1979 and 1983 at 145,300 finfishes, 2,350 lobsters, and 450 conchs. They concluded that the percentage of sportfishing trips with landings had remained fairly stable at about 88% between 1976 and 1983.

This paper reviews available BNP recreational creel census data collected before 1992 when hurricane Andrew disrupted data collection and caused extensive damage to local natural and human resources (Pimm et al., 1994; Tilmant et al., 1994). Our objectives are to: 1) summarize and identify significant changes in recreational landings, 2) compare spearfishing to other recreational fishing modes in terms of selectivity and quantity of landings, and 3) compare recreational landings with fishery-independent, visual abundance estimates made by National Marine Fisheries Service (NMFS) divers.

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ABSTRACT—Recreational creel survey data from 28,923 intercepts collected from Biscayne National Park, Florida and surrounding waters were analyzed for January 1976 through July 1991, prior to disruptions caused by Hurricane Andrew in 1992. A total of 261,268 fish and shellfish representing 170 species or higher taxa were recorded. The average trip landed 9.03 fish and/or shellfish. Mean annual landings per angler were 4.77 fish/angler/trip (from 3.80 in 1991 to 5.83 in 1981) and dropped significantly for each of the 2 years following Florida's adoption of multiple new minimum size limits in 1985 and 1990. The relative contribution to total numerical landings by recreational party type were: skilled anglers (34.0%), food (19.8%), family (14.5%), novice (11.5%), spearfishing (10.3%), lobstering (9.6%), and other (0.3%). Five species or higher taxa accounted for more than 50% of total landings by number: white grunt, Haemulon plumieri*, 15.8%; spiny lobster,* Panulirus argus*, 10.6%; gray snapper,* Lutjanus griseus*, 10.6%; unidentified grunts,* Haemulon *spp., 7.3%; and dolphin,* Coryphaena hippurus*, 6.6%. An average of 4.39 fish or shellfish were reported released per trip. Five taxa accounted for 67% of all releases. Lobster divers reported the highest average release rate (5.73 per trip) and spearfishing the lowest (0.70 per trip). The ratio of releases to landings was 0.49:1 for all taxa, but ranged from 0.03:1 for dolphin to 1.19:1 for unidentified grunts. Spearfishing accounted for 12.0% of the total fishing trips sampled but only 10.3% of the total number organisms landed and 7.6% of all organisms caught. Hogfish,* Lachnolaimus maximus*, accounted for 49% of total spearfishing landings (13,286 of 27,015) and 84.3% of total 15,762 hogfish landed.*

Materials and Methods

Creel census interviews were conducted by BNP personnel and volunteers using standardized data collection procedures (Davis and Thue, 1979). Data collection included a fishing party trip interview and biological sampling of landings conducted at the conclusion of a recreational fishing trip. Anglers were asked to indicate where they fished based on a map showing areas or zones used to partition Biscayne National Park and surrounding waters (Fig. 1). Statistical fishing areas 20 through 24 were added after 1983 as the result of a park boundary extension. Interview data collected included: date of trip, trip hours, number of anglers, hours fished, number, spe-

[1] Tilmant, J. T., and R. Stone. 1984. Reef fish harvest trends, Biscayne National Park Dade County, Florida. *In* 1984 Stock Assessment Workshop. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Ser., Southeast Fish. Sci. Cent., Miami, Fla., 26 p.

cies, and lengths of fish caught, number and species of fish released, preferred species, area fished, angler residence, origin of trip, and fishing party composition. Biological sampling consisted of taking fork or total length measurements of selected organisms in landings. Some length measurements taken during the first two years (1976 and 1977) were specified only at the family level.

Fishing party composition was classified by the interviewer into one of seven possible fishing categories: skilled, family, novice, sustenance (food), spearfishing, lobster diving, and other. Skilled anglers demonstrated expertise in several ways, such as knowledge of park waters, fishing experience, fishing rods rigged with appropriate artificial lures, or fishing in a specialized manner for particular fish. Novice fishermen had little experience fishing or had little experience in the BNP. The family designation applied to groups of adults and children or to groups of adults whose primary interest was other than fishing. Sustenance fishermen were those primarily fishing for food and tended to keep everything caught. Diving parties were classified according to whether the primary purpose was spearfishing or catching spiny lobster, *Panulirus argus*. Divers were not classified in terms of experience (novice or skilled) or purpose (recreation or food).

Data from January 1976 through August 1991 were entered, stored, and analyzed using a Wang[2] computer database at the Everglades National Park (ENP) approximately 30 miles from BNP headquarters. This computer system became obsolete and inoperative before its scheduled replacement. In November 1993, a backup copy (MS DOS format[2]) of all computerized records in the BNP Recreational Creel Census Database was provided to NMFS. The backup consisted of twelve 3.5" high density diskettes with two ASCII data files of recreational interviews (7.1Mb) and fish lengths (5.7Mb). The Fish Length file contained length measurement records of individual fish and spiny lobster as well as data fields for date, species, and interview number. The Recreational Interviews dataset contained all other information provided during each interview. Interview number was the relational field that linked the two datasets.

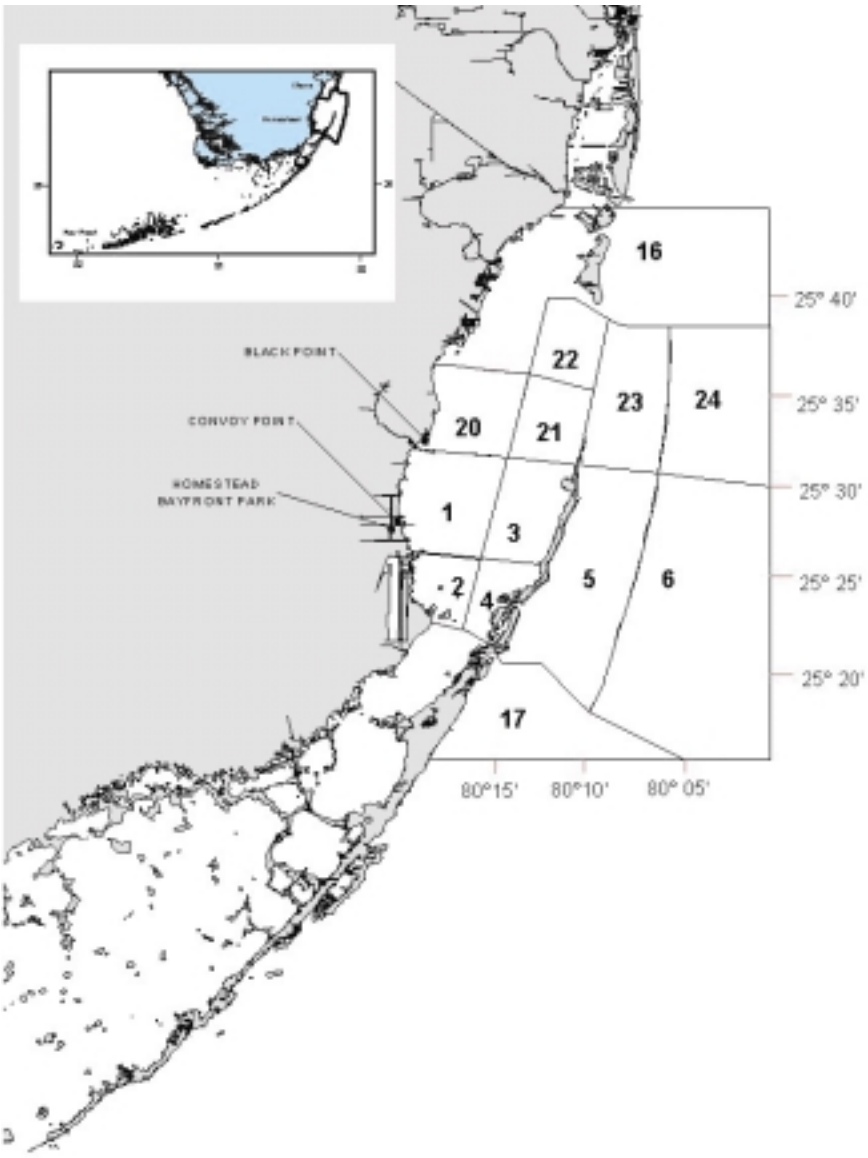

Figure 1.—The 13 statistical areas for reporting fishing trips in Biscayne National Park and surrounding south Florida waters. The inset shows the location of the Park in southern Florida.

The data were reformatted and edited by converting the two ASCII files into two SAS files (version 6.04)[2]. Data were verified and edited for obvious minor data entry errors using the exploratory data analysis and summarization procedures of the SAS System. These error corrections included: reconciliation of duplicate interview numbers and interviews, unrealistic or out of bounds dates and fish sizes, duplicate species kept and released data within a given interview, and some errors in record formatting. Although most data entry errors were in-

[2] Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service or the National Park Service.

tuitively corrected, some (< 1 % of total) questionable or unidentifiable data elements remained unresolved. These involved coded variables for area fished, angler residence, interview location, trip origin, and species which could not be verified. For the purposes of this report, unidentifiable species codes were recoded to miscellaneous fish while all other unresolvable data elements were set to missing variables.

Annual mean landings-per-unit-of-effort (LPUE) and catch-per-unit-of-effort (CPUE) were calculated for selected species. In this report "catch" refers to all organisms caught by recreational fishing while "landings" refers only to organisms caught and brought to shore. "Catch" comprises landings plus organisms reported caught but not brought back to shore, including organisms released (if alive), discarded (if dead), used for bait, or consumed at sea. Fishing effort was measured by angler-hour or trip. Annual rates (fish-per-angler-hour) were obtained using a mean of ratios estimator approach (Malvestuto, 1983) by averaging calculated rates of individual trips successful for the given species during a calendar quarter and then averaging the four quarters. This method was used in previous studies of recreational fisheries in southern Florida (Rutherford et al., 1989a,b; Tilmant et al. 1989).

Scientific and common names of fishes used in this report are according to Robins et al. (1991). Weights were estimated for individual fish by converting measured length to weight according to species specific conversion formulae (Bohnsack and Harper, 1988). Zone usage was analyzed by number of trips and landings. For analytical purposes, trip and landings data were divided equally between relevant zones for interviews indicating use of more than one zone.

A comparison of angling and spearfishing was made for the six most commonly speared species based on mean annual landed fish weight and mean annual total landings per trip. Because data for some species were only collected at the family level from 1976 thru 1978, these years were dropped from some analyses.

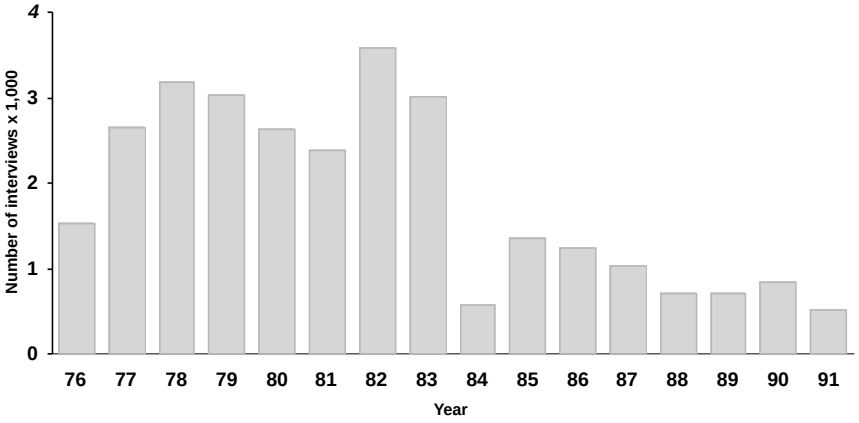

Figure 2.—Number interviews per year (January 1976 through July 1991) for the Biscayne National Park Sportfishing Creel Census.

Results

The BNP Recreational Creel Census Database contained 28,923 interviews completed between January 1976 and July 1991. The mean number of interviews conducted per year was 1,807 with a maximum of 3,587 in 1982 and a minimum of 511 in 1991 (through July only) (Fig. 2). The number of annual interviews dropped significantly after 1983, the second half of the survey period.

Interviews were weighted toward weekends (26,252 or 90.8%), followed by weekdays (2,035 or 7.0%) and holidays (611 or 2.1%). Most interviews (24,768 or 85.7%) were completed during the afternoon between 1:00 and 5:00 when most fishermen were returning to the dock. Over 98% of the interviews were conducted from two locations: Convoy Point (26,037 or 90.0%), the location of BNP headquarters, and Homestead Bayfront Park (2,448 or 8.5%) (Fig. 1). Only 28 interviews reported Black Point Marina as the trip origination site, and those were primarily lobster trips. The high probability of being sampled or encountering a ranger at Convoy Point may have biased the data toward anlers who were particularly conscious of fisheries regulations.

Fishing Party Composition and Species Preferences

Fishing party composition by percentage of total interviews in decreasing order were: skilled, family, novice, spearfishing, lobstering, food, and other (Table 1). During the survey period, the percentage of party types in the food category increased, while the novice category decreased (Fig. 3). The spearfishing component tended to remain fairly stable throughout the survey period, averaging 12% (from 7 to 16%) of the interviewed trips. Composition among fishing groups may have some bias, however, particularly with regard to inflated sampling of lobster fishermen because of concerted sampling effort during the beginning of lobster season and during the annual 2 day spiny lobster recreational miniseason. Also, large changes in party classification for novice and skilled categories observed from 1987 through 1990 may reflect changes in personnel conducting interviews.

Recreational anglers indicated a preference for 66 taxa (Table 2). Excluding the miscellaneous category, the favorite fishing targets by party type or composition were: dolphin, *Coryphaena hippurus*, for skilled recreational, food, family, and novice anglers; unidentified snappers, *Lutjanus* spp., for fishermen classified as "other"; hogfish, *Lachnolaimus maximus*, for spearfishermen; and spiny lobster for divers. For all party types combined, almost half of the interviews (13,847 or 47.9%) indicated no preference for particular species. The next most preferred target categories along with number and percentage of total interviews were: dolphin

Table 1.—Total landings and reported releases in numbers by species or higher taxa by fishing party type in the Biscayne National Park sportfishing creel census (*n* = 28,923 recreational fishing trips sampled from January 1976 through July 1991).

			Skilled recreational		Family		Novice		Spearfishing		Diving lobster		Food		Other		All types	
Family	Scientific name	Common name	Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released
Orectolobidae, Carpet sharks																		
1	*Ginglymostoma cirratum*	Nurse shark	18	58	11	29	5	26	8				12	12			54	125
Carcharhinidae, Requiem sharks																		
2	*Carcharhinus falciformis*	Silky shark	1	1													1	1
3	*Carcharhinus limbatus*	Blacktip shark	9	31	3	1	2	1					2	5			16	38
4	*Carcharhinus* spp.	Unidentified shark	45	133	11	33	12	45	8	1			17	25	1	1	94	238
5	*Negaprion brevirostris*	Lemon shark	10	7	1			1						1			11	9
Sphyrnidae, Hammerhead sharks																		
6	*Sphyrna mokarran*	Great hammerhead	3	9	1	7	2	13					10	1	2		18	30
7	*Sphyrna tiburo*	Bonnethead	14	24	7	9	2	3	1				11	11			35	47
Dasyatidae, Stingrays																		
8	*Dasyatis* spp.	Unidentified stingray		27		25		19	2				1	7			3	78
Elopidae, Tarpons																		
9	*Elops saurus*	Ladyfish	15	188	8	38	9	14					18	32			50	272
10	*Megalops atlanticus*	Tarpon	4	30	1	6	5	4					2	5			12	45
Albulidae, Bonefishes																		
11	*Albula vulpes*	Bonefish	40	233	8	8	6	4	1		20		1	1			76	246
Muraenidae, Morays																		
12	*Gymnothorax moringa*	Spotted moray	1	22		5		11					1	10			2	48
13	*Gymnothorax* spp.	Unidentified moray	8	201		67	3	57	5				5	36			21	361
Clupeidae, Herrings																		
14	N.A.	Unidentified herring			3								524				527	
Synodontidae, Lizardfishes																		
15	*Synodus* spp.	Unidentified lizardfish	6	107	9	61	4	40					4	18			23	226
Ictaluridae, Bullhead catfishes																		
16	N.A.	Unidentified catfish				3			1								1	3
Ariidae, Sea catfishes																		
17	*Arius felis*	Hardhead catfish	4	12		5											4	17
Exocoetidae, Flyingfishes/halfbeaks																		
18	*Hemiramphus brasiliensis*	Ballyhoo	1,980	43	345	15	211	19					130	4	12		2,678	81
Belonidae, Needlefishes																		
19	*Strongylura* spp.	Unidentified needlefish	30	92	10	101	7	73					6	11			53	277
20	*Tylosurus crocodilus*	Houndfish	10	50	12	34	9	19	5				26	34			62	137
Holocentridae, Squirrelfishes																		
21	*Holocentrus adscensionis*	Squirrelfish	13	9	7	12	4	37	1				27	7			52	65
22	*Holocentrus* spp.	Unidentified squirrelfish	3										1				4	
Aulostomidae, Trumpetfishes																		
23	*Aulostomus maculatus*	Trumpetfish	1	6	1	1		2	2								4	9
Centropomidae, Snooks																		
24	*Centropomus ensiferus*	Swordspine snook	6	22					1								7	22
25	*Centropomus undecimalis*	Common snook	48	110	1	2			1		1		1	3			52	115
Serranidae, Sea basses																		
26	*Diplectrum formosum*	Sand perch	266	354	491	390	512	524	2			2	397	100			1,668	1,370
27	*Epinephelus adscensionis*	Rock hind	103	36	42	23	23	18	23				27	32			218	109
28	*Epinephelus cruentatus*	Graysby	164	108	154	120	73	8	42				222	151	7		662	387
29	*Epinephelus drummondhayi*	Speckled hind	2										1				3	
30	*Epinephelus flavolimbatus*	Yellowedge grouper		5	4			1	8								12	6
31	*Epinephelus fulvus*	Coney	13	14	6	4	5	1	3				3	4			30	23
32	*Epinephelus guttatus*	Red hind	253	154	123	90	74	95	69		2		105	54	1		627	393
33	*Epinephelus inermis*	Marbled grouper							1								1	
34	*Epinephelus itajara*	Jewfish	1			1		3	6		1						8	4
35	*Epinephelus morio*	Red grouper	1,017	283	403	131	275	26	851	1	26		422	177	10	25	3,004	643
36	Epinephelus striatus	Nassau grouper	369	72	132	41	141	31	809		22	1	133	48	4		1,610	193
37	*Mycteroperca bonaci*	Black grouper	351	59	122	48	88	10	765	1	9		92	34	2		1,429	152
	Mycteroperca interstitialis	Yellowmouth grouper	30		8		5		14		1		6				64	
39	*Mycteroperca microlepis*	Gag	295	81	94	34	54	15	77		1		63	34			584	164
40	*Mycteroperca phenax*	Scamp	12				3		6								21	
41	*Mycteroperca venenosa*	Yellowfin grouper	27	2	5		2	1	30				1	1			65	4
42	*Paranthias furcifer*	Creole-fish	3				2										5	
43	N.A.	Unidentified grouper	2,198	1,230	693	897	709	552	1,812	16	102	1	719	529	43	19	6,276	3,244

Continued

Table 1.—(Continued).

Family	Scientific name	Common name	Skilled recreational		Family		Novice		Spearfishing		Diving lobster		Food		Other		All types	
			Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released
Grammistidae, Soapfishes																		
44	*Rypticus saponaceus*	Greater soapfish		1	1												1	1
Priacanthidae, Bigeyes																		
45	*Priacanthus arenatus*	Bigeye	277	43	115	60	103	16	41		3		227	24	1		767	143
46	N.A.	Unidentified bigeye	4			15			1		2						7	15
Malacanthidae, Tilefishes																		
47	*Malacanthus plumieri*	Sand tilefish	65	186	54	99	49	135	2				43	50			213	470
48	N.A.	Unidentified tilefish			5	1	5										10	1
Pomatomidae, Bluefishes																		
49	*Pomatomus saltatrix*	Bluefish	72	17	10		18	13					9	1		15	109	46
Rachycentridae, Cobias																		
50	*Rachycentron canadum*	Cobia	12	3	1								3				16	3
Echeneidae, Remoras																		
51	*Echeneis naucrates*	Sharksucker	1	10	3	2		5					3	8			7	25
Carangidae, Jacks																		
52	*Alectis ciliaris*	African pompano	22	2	8		8	1	3				3				44	3
53	*Caranx bartholomaei*	Yellow jack	123	67	65	4	18	14	175		3		126	3	7	1	517	89
54	*Caranx crysos*	Blue runner	1,071	892	1,019	715	532	432	67	43	6		1,173	501	5		3,873	2,583
55	*Caranx hippos*	Crevalle jack	92	201	83	101	104	62	20				83	70			382	434
56	*Caranx latus*	Horse-eye jack	8	9	8	2	8		2				4	4			30	15
57	*Caranx ruber*	Bar jack	42	65	15	11	35	7	34	1			27	4			153	88
58	*Caranx* spp.	Unidentified jack	283	676	176	393	196	356	120	1	11		215	75	5		1,006	1,501
59	*Decapterus macarellus*	Mackerel scad	36	7	3								12	4			51	11
60	*Elagatis bipinnulata*	Rainbow runner	11	10	7	1	1	12	4				1				24	23
61	*Oligoplites saurus*	Leatherjacket	6	3	10	2	20	1					16	13			52	19
62	*Selene vomer*	Lookdown	76	7	29	1	1	1					34	1			140	10
63	*Seriola dumerili*	Greater amberjack	168	46	26	27	15	9	59	1			12	3			280	86
64	*Seriola rivoliana*	Almaco jack	4		9								5	11			18	11
65	*Trachinotus carolinus*	Florida pompano	3	1			2	1					2	1			7	3
66	*Trachinotus falcatus*	Permit	10	7	3		5		16		2		1				37	7
Coryphaenidae, Dolphins																		
67	*Coryphaena equisetis*	Pompano dolphin	1										1				2	
68	*Coryphaena hippurus*	Dolphin	13,283	408	1,525	47	639	15	30	4			1,845	71	12	3	17,334	548
Lutjanidae, Snappers																		
69	*Etelis oculatus*	Queen snapper			7									3			7	3
70	*Lutjanus analis*	Mutton snapper	1,326	127	463	97	202	23	364		12		434	99	6	10	2,807	356
71	*Lutjanus apodus*	Schoolmaster	205	25	129	29	42	20	252		5		132	32	3		768	106
72	*Lutjanus buccanella*	Blackfin snapper	3		2		1		1								7	
73	*Lutjanus campechanus*	Red snapper	14	1	1	7	2	1									17	9
74	*Lutjanus cyanopterus*	Cubera snapper	2		3	1			16								21	1
75	*Lutjanus griseus*	Gray snapper	9,976	4,889	5,279	2,839	3,792	1,725	1,432	16	120	35	7,016	2,215	73	27	27,688	11,746
76	*Lutjanus jocu*	Dog snapper	9	1	13	2	15		63		1		7				108	3
77	*Lutjanus mahogoni*	Mahogany snapper	13	1	2				10				6	2			31	3
78	*Lutjanus* spp.	Unidentifed snapper	5,959	1,340	2,642	1,041	2,348	878	718	11	46	15	3,087	230	95	3	14,895	3,518
79	*Lutjanus synagris*	Lane snapper	609	79	239	71	258	51	21				435	159			1,562	360
80	*Lutjanus vivanus*	Silk snapper	9	2					3				4				16	2
81	*Ocyurus chrysurus*	Yellowtail snapper	7,217	4,461	2,074	2,395	1,831	1,212	178	7	18		3,107	2,077	5	10	14,430	10,162
82	*Rhomboplites aurorubens*	Vermilion snapper	26	10	11				11								48	10
Lobotidae, Tripletails																		
83	*Lobotes surinamensis*	Tripletail	42	6	2		4						6				54	6
Gerreidae, Mojarras																		
84	*Gerres cinereus*	Yellowfin mojarra	2	2	5	5	28	11	1				29	1			65	19
Haemulidae, Grunts																		
85	*Anisotremus surinamensis*	Black margate	27	2	23	1	10	7	147		6		42	13			255	23
86	*Anisotremus virginicus*	Porkfish	51	6	40	28	43	32	18				95	25			247	91
87	*Haemulon album*	Margate	173	35	108	8	32	12	75		5		134	18			527	73
88	*Haemulon aurolineatum*	Tomtate	35		37	2	25	34					99	5			196	41
89	*Haemulon carbonarium*	Caesar grunt	22	1	14		3	3	8				24	2			71	6
90	*Haemulon chrysargyreum*	Smallmouth grunt			3		4						1				8	
91	*Haemulon flavolineatum*	French grunt	104	64	62	21	48	7	5				43				262	92
92	*Haemulon macrostomum*	Spanish grunt	6	10	17		4		20				28	13			75	23
93	*Haemulon parrai*	Sailor's choice	210	172	208	95	103	74	5				160	45			686	386
94	*Haemulon plumieri*	White grunt	12,509	6,911	8,850	3,722	6,323	3,463	309	92	26	15	13,262	3,409	89	48	41,368	17,660

Continued

Table 1.—(Continued).

Family	Scientific name	Common name	Skilled recreational		Family		Novice		Spearfishing		Diving lobster		Food		Other		All types	
			Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released
95	*Haemulon sciurus*	Bluestriped grunt	3,442	1,762	2,427	1,332	1,723	893	202	4	6	1	2,841	538	51	16	10,692	4,546
96	*Haemulon* spp.	Unidentified grunt	5,761	8,711	3,448	5,846	3,606	5,707	277	125	25	27	5,706	2,216	223	60	19,046	22,692
97	*Haemulon striatum*	Striped grunt	4		7		3	9	1				24	2			39	11
98	*Orthopristis chrysoptera*	Pigfish	17	4	19	14	10	12					30				76	30
Sparidae, Porgies																		
99	*Archosargus probatocephalus*	Sheepshead	68	1	20	5	21	2	16				26	5			151	13
100	*Archosargus rhomboidalis*	Sea bream	71	32	55	46	30	20	4				56	13			216	111
101	*Calamus arctifrons*	Grass porgy	6		35		9	6	1				9	1			60	7
102	*Calamus bajonado*	Jolthead porgy	4,708	571	1,584	213	1,676	340	95		11		2,576	74	24		10,674	1,198
103	*Calamus calamus*	Saucereye porgy	500	15	232	36	206	12	12		3		258	24	5		1,216	87
104	*Calamus nodosus*	Knobbed porgy	2		3								5				10	
105	*Calamus proridens*	Littlehead porgy	3		2		1						41	2			47	2
106	*Calamus* spp.	Unidentifed porgy	30	15	37	47	11	17					8	9		8	86	96
107	*Lagodon rhomboides*	Pinfish	1,354	2,091	627	1,070	569	1,040	3				762	400			3,315	4,601
Sciaenidae, Drums																		
108	*Cynoscion nebulosus*	Spotted seatrout	1,036	477	164	96	182	96					122	97			1,504	766
Mullidae, Goatfishes																		
109	*Mulloidichthys martinicus*	Yellow goatfish	1	4		1			4				1				6	5
110	*Pseudupeneus maculatus*	Spotted goatfish	2	3	1		2				1		2	1			8	4
Kyphosidae, Sea chubs																		
111	*Kyphosus incisor*	Yellow chub	11		25	9	8	1	3				4				51	10
112	*Kyphosus sectatrix*	Bermuda chub	118	62	98	29	122	34	30		3		86	34			457	159
113	*Kyphosus* spp.	Unidentified chub	15	15	24	7		11	3				39	8			81	41
Ephippidae, Spadefishes																		
114	*Chaetodiperus faber*	Atlantic spadefish	1	1	5	4	1		37		4		3	1			51	6
Pomacanthidae, Angelfishes																		
115	*Holacanthus ciliaris*	Queen angelfish		2	2	1			2					1			4	4
116	*Pomacanthus arcuatus*	Gray angelfish							2								2	
117	*Pomacanthus paru*	French angelfish	1														1	
118	N.A.	Unidentified anglefish	5	46	10	28	6	24	33				8	21			62	119
Pomacentridae, Damselfishes																		
119	*Abudefduf saxatilis*	Sergeant major		4		11	1										1	15
Labridae, Wrasses																		
120	*Bodianus rufus*	Spanish hogfish	8	4	9		2		15		1		5				40	4
121	*Halichoeres bivittatus*	Slippery dick	5	2	6				11				5				27	2
122	*Halichoeres radiatus*	Puddingwife	12	4	11	43	18	18	1				33	47		1	75	113
123	*Halichoeres* spp.	Unidentified wrasse	7	38	28	35	16	32	1				11	16			63	121
124	*Lachnolaimus maximus*	Hogfish	1,046	145	318	73	260	15	13,286	15	380		429	97	43	4	15,762	349
Scaridae, Parrotfishes																		
125	*Scarus guacamaia*	Rainbow parrotfish	3	5	1	6	4	3	5				4				17	14
126	N.A.	Unidentified parrotfish	36	343	70	200	39	114	71	1	1	1	71	95		2	288	756
Mugilidae, Mullets																		
127	*Mugil* spp.	Unidentified mullet	88	7	8	1							136				232	8
Sphyraenidae, Barracudas																		
128	*Sphyraena barracuda*	Great barracuda	2,890	2,205	911	515	761	523	161	16	19	8	1,173	296	41	2	5,956	3,565
129	*Sphyraena picudilla*	Southern sennet	1														1	
Acanthuridae, Surgeonfishes																		
130	*Acanthurus bahianus*	Ocean surgeon	2	7	3	2	3	1	2				1	1			11	11
131	*Acanthurus chirurgus*	Doctorfish	11	6	10	3	5	1					17	12			43	22
132	*Acanthurus coeruleus*	Blue tang	1	1	11	1		3	1				1	1			14	6
Scombridae, Mackerels/Tunas																		
133	*Acanthocybium solandri*	Wahoo	123	2	17		3		1				17	1	1	1	162	4
134	*Euthynnus alletteratus*	Little tunny	70	17	10	8	1	4					29	18			110	47
135	*Katsuwonus pelamis*	Skipjack tuna	23	2	5		3						10	1			41	3
136	*Sarda sarda*	Atlantic bonito	287	177	45	36	50	32	2				12	17		1	396	263
137	*Scomberomorus cavalla*	King mackerel	165	10	18	9	16		2				28				229	19
138	*Scomberomorus maculatus*	Spanish mackerel	182	7	32	1	42	9	21	1			20	4			297	22
139	*Scomberomorus regalis*	Cero mackerel	618	16	150	13	109	4	53		2		142	7			1,074	40

Continued

Table 1.—(Continued).

Family	Scientific name	Common name	Skilled recreational		Family		Novice		Spearfishing		Diving lobster		Food		Other		All types	
			Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released	Landed	Released
140	*Thunnus albacares*	Yellowfin tuna	1														1	
141	*Thunnus atlanticus*	Blackfin tuna	37	3	7	2	3						2	2			49	7
142	*Thunnus obesus*	Bigeye tuna				2							3				3	2
143	*Thunnus* spp.	Unidentified tuna	278	41	50	17	90	19	14			2	23	2	1		456	81
Xiphiidae, Swordfishes																		
144	*Xiphias gladius*	Swordfish											6				6	
Istiophoridae, Billfishes																		
145	*Istiophorus platypterus*	Sailfish	65	17	4	2	4						2	2			75	21
146	*Makaira nigricans*	Blue marlin	1														1	
147	N.A.	Unidentified billfish	353														353	
Scorpaenidae, Scorpionfishes																		
148	*Scorpaena* spp.	Unidentified scorpionfish		21	1	12	1	7					1	6			3	46
Triglidae, Searobins																		
149	*Prionotus* spp.	Unidentified searobin		3		3			1					1			1	7
Bothidae, Lefteye flounders																		
150	*Bothus lunatus*	Peacock flounder									1						1	
151	N.A.	Unidentified lefteye flounder	1	1	4	2	8		4				2				19	3
Balistidae, Leatherjackets																		
152	*Aluterus scriptus*	Scrawled filefish	1	3	3		2	1					3	3			9	7
153	*Balistes capriscus*	Gray triggerfish	70	65	91	42	57	12	6		1		95	28	3		323	147
154	*Balistes vetula*	Queen triggerfish	29	32	14	14	16	10	4				38	16	1		102	72
155	*Cantherhines pullus*	Orangespotted filefish	0	24	5	7	1	3	2				1				9	34
156	*Canthidermis sufflamen*	Ocean triggerfish	220	126	130	55	109	51	32	2	4		168	51	10		673	285
157	N.A.	Unidentifed filefish	6	34	4	13	2	10	1				8	2			21	59
Ostraciidae, Boxfishes																		
158	*Lactophrys* spp.	Unidentified boxfish	11	24	23	61	14	19	4		1		23	16			76	120
159	*Lactophrys trigonius*	Trunkfish	7	10	2	6	2	5					4	3			15	24
Tetraodontidae, Puffers																		
160	*Diodon hystrix*	Porcupinefish				15	1										1	15
161	*Sphoeroides* spp.	Unidentified puffer	7	84	11	108	8	130	1				7	57			34	379
162	N.A.	Unidentified fishes	1,088	1,036	304	625	393	733	139	4	19	2	1,100	130	21	6	3,064	2,536
Invertebrates																		
163	*Calinectes sapidus*	Bluecrab	221	4	82	13	34	3			48		90	8			475	28
164	*Menippe mercenaria*	Stone crab									3		1			1	4	1
165	*Mithrax* spp.	Unidentified spidercrab									1						1	
166	*Panulirus argus*	Caribbean spiny lobster	1,902	1,882	286	141	548	635	2,623	2,014	21,938	17,813	386	580	35	4	27,718	23,069
167	*Panulirus guttatus*	Spotted lobster	4		4				10		21						39	
168	*Pennaeus duorarum*	Pink shrimp			30												30	
169	*Scyllarides aequinoctialis*	Shovel-nosed lobster	1						13		25						39	
170	*Strombus gigas*	Queen conch	136		50		86		1,018	50	2,227	77			10		3,527	127
	Total		88,765	44,843	37,718	24,967	30,022	20,927	27,015	2,427	25,196	18,000	51,700	15,546	852	268	261,268	126,978
	No. interviews		9,244	9,244	5,199	5,199	5,071	5,071	3,473	3,473	3,142	3,142	2,647	2,647	147	147	28,923	28,923
	Avg. trip landings		9.60		7.25		5.92		7.78		8.02		19.53		5.80		9.03	
	% Total landings		34.0%		14.4%		11.5%		10.3%		9.6%		19.8%		0.3%			
	Avg. Trip Releases			4.85		4.80		4.13		0.70		5.73		5.87		1.82		4.39
	% Total Releases			35.3%		19.7%		16.5%		1.9%		14.2%		12.2%		0.2%		

(4,315 or 14.9%), spiny lobster (3,381 or 11.7%), unidentified snappers (1,501 or 5.2%), unidentified groupers (1,375 or 4.8%), and hogfish (880 or 3.0%).

Landings

A total of 261,268 fish and shellfish representing 170 species or higher taxa were recorded in recreational creel samples (Table 1). Five species or higher taxa accounted for more than 50% of total number of organisms landed: white grunt, *Haemulon plumieri* (15.8%); spiny lobster (10.6%); gray snapper, *Lutjanus griseus* (10.6%); unidentified grunts, *Haemulon* spp. (7.3%); and dolphin (6.6%).

Average annual LPUE for all 28,923 interviews was 4.77 fish/angler/trip (from 3.80 in 1991 to 5.83 in 1981) (Fig. 4). Mean LPUE increased from 1976 through 1981 and then declined with large fluctuations between 1984 and 1991. The 95% confidence intervals suggest that observed significant drops in landings per angler-trip during 1985 and 1986 were unlikely to be anomalies caused by smaller sample sizes. We conclude that this drop was most likely the temporary result of several new recreational fishery regulations. During the study period, several landings regulations were implemented that may have influenced landings. In September 1983 minimum size limits of 12 inches (30.5 cm) were established for black grouper, *Mycteroperca bonaci*; and yellowtail snapper, *Ocyurus crysurus*; for Federal waters (>3 n.mi. from land), areas mostly outside the study area. On 29 July 1985, Florida established minimum size limits much more likely to influence BNP landings since they applied to state waters (< 3 n.mi. from land). These new minimum size limits applicable to state waters were 12 inches (30.5 cm) for yellowtail snapper, and mutton snapper, *Lutjanus analis*; and 18 inches (45.7 cm) for black grouper; yellowfin grouper, *Mycteroperca venenosa*; gag, *M. microlepis*; red grouper, *Epinephelus morio*; and Nassau grouper, *E. striatus*. In December 1986, bag limits were established of 10 snappers and 5 groupers per angler per day. In February 1990, Florida added or increased minimum size limits to 8 inches (20.3 cm) for vermilion snapper, *Rhomboplites aurorubens*; and lane snapper, *L. synagris*; 10 inches (25.4 cm) for gray snapper, *L. griseus*; and schoolmaster, *L. apodus*; 20 inches (50.8 cm) for scamp, *M. phenax*; yellowmouth grouper, *M. interstitalis*; black, gag, red, yellowfin, and Nassau groupers; and 28 inches (71.1 cm) for greater amberjack, *Seriola dumerili*. Again, the reported average annual landings per angler-trip declined significantly in 1990 and 1991, the years during and following the application of new minimum size limits (Fig. 4).

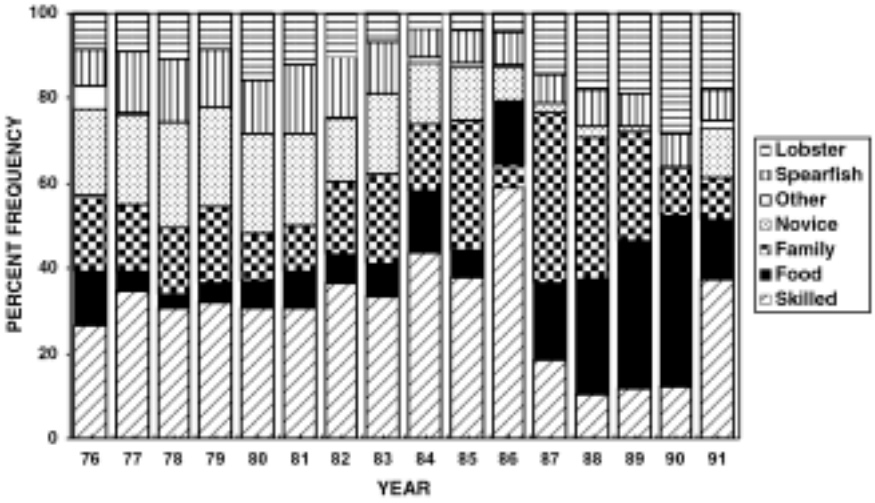

Figure 3.—Composition of recreational fishing trips by party type (January 1976–July 1991). Sample sizes are shown in Figure 2.

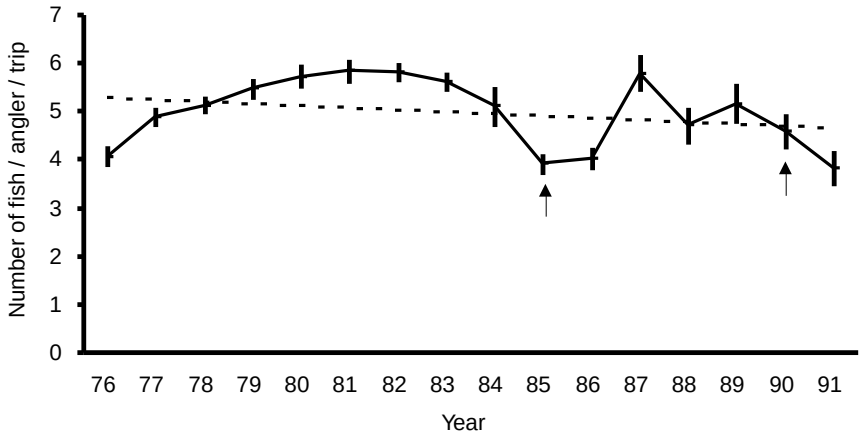

Figure 4.—Mean number of fish landed per person per trip (± 95% C.I.) for the Biscayne National Park Sportfishing Creel Census. The dotted line shows the linear trend for 28,923 trip interviews. Arrows show when multiple minimum size limits became effective in Florida. Sample sizes are shown in Figure 2.

Tilmant (1981) reported an inverse relationship between average landings and total trips. Years with more trips had lower average LPUE values while years with fewer trips had higher LPUE values. Thus, the decline in LPUE between 1982 and 1991 also may reflect an increased total number of fishing trips, although data were not available to estimate total annual number of trips. Previous studies used trailer counts to estimate total fishing trips based upon a correlation between trailers and aerial counts of fishing vessels, but these data were unavailable after 1985. Boat trailer counts and total fishing trips are known to be highly af-

fected by weather, day of the week, holiday occurrence, and special events, such as the opening of spiny lobster season. In general, more fishing trips are made during special marine-related events or on the weekends with good boating conditions, while fewer fishing trips occur during major local sporting events or inclement weather conditions. Also, without information on the total number of trips, we were not able to estimate total annual catch or landings in BNP.

Table 2.—Species preferences as a percent of interviews (*n* = 28,923) by recreational fishing party type. Species listed in less than 1% of interviews by party type are shown by **. Scientific names are shown in Table 1.

Common name	Skilled recreational	Family	Novice	Spear fishing	Diving lobster	Food	Other	All types
Atlantic bonito	**	**						**
Atlantic spadefish	**							**
Ballyhoo	**							**
Bigeye	**							**
Black grouper				**				**
Blue runner	**	**	**					**
Bluecrab	**		**		**	**		**
Bluefish	**		**					**
Bluestriped grunt		**						**
Bonefish	5.7%	**	**		**	**		2.1%
Caribbean spiny lobster	2.0%	**	1.8%	5.9%	88.9%	2.6%	4.8%	11.7%
Cero mackerel	**	**	**			**		**
Cobia	**							**
Common snook	**	**	**	**		**		**
Creole wrasse						**		**
Crevalle jack			**					**
Cubera snapper	**					**		**
Dolphin	30.4%	11.7%	9.3%	**	**	15.2%	8.2%	14.9%
French grunt	**							**
Gag	**							**
Gray snapper	2.6%	2.5%	1.9%	**		3.9%	**	2.0%
Gray triggerfish		**						**
Great barracuda	2.5%	2.3%	1.6%	**		3.0%	5.4%	1.8%
Greater amberjack	**	**	**			**		**
Hogfish	**	**	**	23.1%	**	**	**	3.0%
Jolthead porgy	**	**	**			**		**
King mackerel	**	**	**			**	**	**
Longnose sucker	**							**
Lookdown	**							**
Mutton snapper	1.7%	**	**	**		1.1%	**	**
Nassau grouper				**				**
Nurse shark			**					**
Painted wrasse	**			**				**
Permit	**		**					**
Pinfish			**					**
Queen conch	**			**	3.6%	**		**
Red grouper	**	**		**				**
Red snapper	**	**	**					**
Sailfish	1.7%	**	**	**	**	**	1.4%	**
Sand perch	**	**	**			**		**
Schoolmaster	**							**
Sheepshead	**					**		**
Shovel-nosed lobster	**			**	**			**
Skipjack tuna	**							**
Spanish mackerel	**	**	**			**		**
Spottail pinfish		**						**
Spotted seatrout	2.3%	1.4%	2.0%			1.2%	1.4%	1.4%
Stone crab					**			**
Swordspine snook	**							**
Tarpon	**	**	**			**		**
Unidentified porgy	**	**	**			**	**	**
Unidentified snapper	5.5%	6.1%	6.2%	3.0%	**	8.7%	15.0%	5.2%
Unidentified billfishes	**	**	**					**
Unidentified dolphin	**							**
Unidentified fishes	35.5%	67.6%	69.3%	52.7%	6.2%	54.9%	49.7%	47.9%
Unidentified groupers	4.6%	3.1%	3.8%	13.2%	**	4.3%	8.8%	4.8%
Unidentified grunt	**	**	**	**		1.1%	**	**
Unidentified jack	**	**	**	**		**	**	**
Unidentified shark	**	**	**	**		**		**
Unidentified snook	**							**
Unidentified tuna	1.1%	**	**			**	**	**
Unidentified wrasse				**				**
Wahoo	**	**				**		**
White grunt	**	**	**			**		**
Yellow jack				**				**
Yellowtail snapper	**	**	**	**	**	1.2%		**

An average of 9.03 finfish or shellfish were landed per trip for all interviews (Table 1). Parties classified in the "food" category had the highest average trip landings of 19.53, followed by skilled recreational (9.60), lobster diving (8.02), and spearfishing (7.78). Fishing parties classified as "other" had the lowest average landings of 5.80 per trip. The relative contribution by each party type to total numerical landings sampled was: skilled recreational (34.0%), food (19.8%), family (14.5%), novice (11.5%), spearfishing (10.3%), lobster diving (9.6%), and other (0.3%) (Table 1). The four angling party types showed broad overlap in landings composition (Table 1). Lobster diving and "other" categories were distinctive by landing very few species. Spearfishermen showed intermediate selectivity by concentrating on hogfish, groupers, jacks, snappers, and grunts (Table 1).

Releases

Recreational fishermen reported releasing 126,978 fish and shellfish in trip interviews, representing 147 species or higher taxa (Table 1). Five taxa accounted for approximately 67% of total organisms released: spiny lobster (18.2%), unidentified grunts (17.9%), white grunt (13.9%), gray snapper (9.3%), and yellowtail snapper (8.0%). The average trip release rate for all interviews was 4.39 fishes or shellfish per trip. Lobster divers reported more releases per trip (5.73) than any other fishing party type, probably because minimum size limits existed on spiny lobster throughout the study period. A total of 17,600 organisms released by lobster divers were mostly spiny lobster (97.8%). Spearfishing parties reported the fewest average releases per trip (0.70) reflecting the selectivity of their fishing gear and methods that target individual fishes. This number does not include organisms that may have escaped capture after being speared.

A comparison was made of landings and releases for the ten most commonly landed taxa (Table 3). The four most commonly landed taxa (white grunt, spiny lobster, gray snapper, and unidentified grunts) also ranked within the top ten released taxa. Only three of the top

ten landed species failed to rank within the top ten releases: dolphin (rank 19); hogfish (rank 29); and jolthead porgy, *Calamus bajonado* (rank 15). The release to landings ratio for all taxa was 0.49:1. The ratio was lowest for dolphin (0.03:1) and highest for unidentified grunts (1.19:1).

Length Measurements

A total of 70,687 length measurements were recorded, representing 149 taxa and 27.1% of all landings. The average annual number of organisms measured was 4,418 (range: 1,417 in 1991 to 7,049 in 1985). The percentage of total individuals measured was highly variable between species, ranging from 1.29% for unidentified grunts to 100% for 17 species or higher taxa. The 10 species with the most measured individuals were: spiny lobster (16,527), white grunt (10,125), gray snapper (8,756), hogfish (5,077), dolphin (4,911), yellowtail snapper (3,891), bluestriped grunt, *Haemulon sciurus* (3,348), red grouper (1,941), mutton snapper, (1,516), and great barracuda, *Sphyraena barracuda* (1,398).

Areas Fished

Trip interviews reported fishing activity in various spatial combinations of 13 zones used by the Park Service in southern Florida (Fig. 1, Table 4). The distribution of total trips and total landings among zones is shown in Figure 5. Spearfishing trips showed the most restrictive use patterns by concentrating 84% of their trips in areas 5 and 6. The remaining party types had similar patterns of area usage mostly concentrating in zones 2, 4, 5, and 6. Zones 5 and 6 accounted for most trips (57.5%) and landings (54.0%). Only 9.9% of trips and 11.0% of landings were reported from trips that visited multiple zones.

The areas with the highest mean total catch per trip were: Statistical Area 20—Biscayne Bay, northeastern corner of BNP (17.6 fish or shellfish per trip, SE = 4.7); Area 17—south of BNP (17.5 fish or shellfish per trip, SE = 0.8); Areas 2 and 4—Biscayne Bay, southern portion within BNP (17.0 fish or shellfish per trip, SE = 2.9). Although Area 20 had the highest catch compared with other areas, the sample size was small (n = 47) and the variability (SE = 4.7) was the largest computed for all areas. Statistical fishing areas 20 through 26 were added after 1983 as the result of a boundary extension for BNP (Table 5). In July 1984 southern Biscayne Bay (regions 1–4 and 20–22) were closed to spiny lobster fishing.

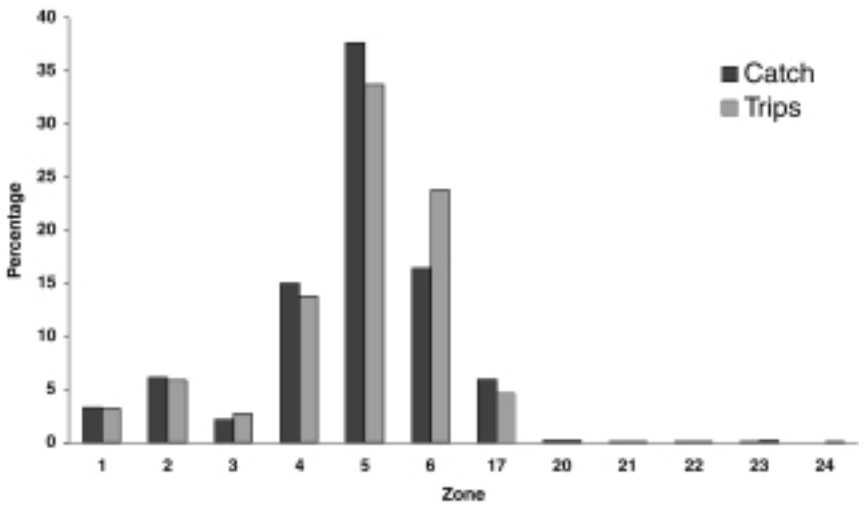

Figure 5.—Distribution by percentage of trips and catch (landings and releases) in BNP statistical reporting areas from 1976–1991 (n = 28,923 trips; 388,246 organisms).

Table 3.—Comparison of landings and releases for the 10 most commonly landed taxa.

	Landings			Releases			Release to landings ratio
Common name	Number	% Total	Rank	Number	% Total	Rank	
White grunt	41,368	15.83	1	17,660	13.91	3	0.43:1
Caribbean spiny lobster	27,718	10.61	2	23,069	18.17	1	0.83:1
Gray snapper	27,688	10.60	3	11,746	9.25	4	0.42:1
Unidentified grunts	19,046	7.29	4	22,692	17.87	2	1.19:1
Dolphin	17,334	6.63	5	548	0.43	19	0.03:1
Hogfish	15,762	6.03	6	349	0.27	29	0.02:1
Unidentified snappers	14,895	5.70	7	3,518	2.77	9	0.24:1
Yellowtail snapper	14,430	5.52	8	10,162	8.00	5	0.70:1
Bluestriped grunt	10,692	4.09	9	4.546	3.58	7	0.43:1
Jolthead porgy	10,674	4.09	10	1,198	0.94	15	0.11:1

Spearfishing

A total of 3,473 recreational spearfishing trips were sampled between January 1976 and July 1991 (mean 217 trips per year, range 37 for partial 1991 to 491 in 1982). Annual composition of sampled landings was determined for the 110 species or higher taxa recorded from spearfishing trips (Table 6). An average 7.78 organisms were landed per spearfishing trip (range 5.23 in 1986 to 9.71 in 1983) (Fig. 6). Spearfishing accounted for about 12.0% of the total fishing trips sampled but only 10.3% of the total number of organisms landed and 7.6% of all organisms caught (n = 388,246).

Spearfishing was more selective than angling. Hogfish accounted for almost half (49%) of the organisms speared (13,286 of 27,015) and 84.3% of the 15,762 hogfish landed. Speared hogfish averaged 35.06 cm FL (SD = 9.05 cm, Fig. 7). In 1994, after the study period, Florida enacted a 12 inch (30.5 cm) FL minimum size limit along with a daily bag limit of five hogfish per person. The median annual hogfish fork length over the study period was 33 cm (from 29 cm in 1976 to 36 cm in 1986, Fig. 8). A total of 34.8% of the measured hogfish were below 12 inches (30.5 cm) FL, the minimum size limit established after the study period.

Table 4.—Patterns of zone usage based on percentage of trips and catch numbers (landings + releases) reported in trip interviews by fishing party type from January 1976 through July 1991.

	Fishing party type															
	Experienced		Family		Novice		Spearfishing		Lobster diving		Food		Other		Total	
Fishing zones	% Trips	% Catch	% Trips	% Catch	% Trips	% Catch	% Trips	% Catch	% Trips	% Catch	% Trips	% Catch	% Trips	% Catch	% Trips	% Catch
Area 1	2.6	3.3	4.3	3.8	5.9	5.4	0.2	0.1	1.2	2.2	3.6	3.1	9.5	0.7	3.2	3.3
Area 2	5.4	5.4	8.7	8.4	8.0	7.6	0.4	0.4	1.7	3.0	9.3	8.6	8.2	4.8	5.8	6.1
Area 3	1.7	1.6	5.3	3.3	4.5	3.5	0.6	0.4	1.3	0.8	2.1	2.7	2.7	2.4	2.7	2.2
Area 4	10.0	11.7	20.2	20.2	18.9	18.6	4.1	3.0	16.5	23.3	14.0	13.7	17.7	16.4	13.8	15.0
Area 5	24.0	32.9	26.4	34.2	26.3	32.3	64.3	65.4	53.1	43.8	32.9	38.0	32.0	39.3	33.7	37.6
Area 6	38.0	23.8	16.7	11.0	18.3	11.9	21.5	21.3	8.5	6.5	20.7	14.3	13.6	12.8	23.8	16.4
Areas 1,2	0.6	0.8	0.8	0.7	0.9	0.9	0.1	0.0	0.3	0.4	0.9	0.9	2.0	9.2	0.6	0.8
Areas 1,3	0.3	0.2	0.3	0.4	0.5	0.3	0.0	0.0	0.2	0.1	0.3	0.4	0.7	0.2	0.3	0.3
Areas 2,4	0.9	0.8	1.3	1.4	1.0	0.7	0.1	0.0	0.4	0.7	0.8	2.1	0.0	0.0	0.8	1.0
Areas 3,4	0.5	0.5	1.3	1.0	1.1	0.6	0.2	0.2	0.3	0.4	0.5	0.4	0.7	0.4	0.7	0.5
Areas 1,2,3,4	0.3	0.2	0.3	0.2	0.7	0.5	0.0	0.1	0.1	0.1	0.2	0.1	7.5	5.1	0.4	0.2
Areas 3,5	0.3	0.3	0.6	0.5	0.4	0.4	0.1	0.0	0.1	0.2	0.5	0.6	0.0	0.0	0.3	0.4
Areas 4,5	2.3	2.4	2.7	3.0	2.3	2.5	1.1	0.8	2.7	3.0	2.6	3.2	0.0	0.0	2.3	2.6
Areas 3,4,5	0.3	0.3	0.4	0.5	0.4	0.4	0.1	0.0	0.2	0.2	0.5	0.5	0.7	1.0	0.3	0.4
Areas 5,6	5.7	6.8	3.6	3.6	3.5	4.1	4.1	4.4	1.1	1.2	5.4	5.3	1.4	0.3	4.2	4.8
Area 16(N. of BNP)	0.3	0.2	0.4	0.3	0.4	0.3	0.5	0.4	0.5	0.5	0.2	0.1	0.7	1.8	0.3	0.3
Area 17(S. of BNP)	4.6	6.4	4.8	5.4	4.2	6.8	2.0	2.2	9.1	10.3	3.8	4.2	2.0	2.0	4.7	6.0
Other	1.7	1.9	1.2	1.6	2.4	2.5	0.5	1.0	1.6	2.6	1.0	1.3	0.0	0.0	1.5	1.8
Area 20	0.2	0.2	0.3	0.2	0.1	0.5	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.2	0.2
Area 21	0.1	0.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.1
Area 22	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.7	3.6	0.0	0.1
Area 23	0.1	0.0	0.1	0.1	0.1	0.0	0.2	0.1	1.1	0.7	0.2	0.1	0.0	0.0	0.2	0.1
Area 24	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0
Total Trips	9,244		5,199		5,071		3,473		3,142		2,647		147		28,923	
Total Catch (no.)		133,608		60,685		50,949		29,442		43,196		67,246		1,120		388,246

Table 5.—Percentage of recreational fishing trips (*n* = 28,923) reported using BNP statistical fishing areas by year. Annual sample sizes are shown in Figure 1. Areas 20–24 were added after BNP boundary expansion in 1993.

Fishing zones	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Area 1	2.0	2.9	6.8	3.2	1.6	2.7	4.5	4.0	4.0	2.2	2.1	1.5	0.7	1.1	0.2	0.2
Area 2	5.2	4.7	3.4	6.5	8.3	3.6	4.6	9.2	9.5	6.7	7.7	6.3	5.1	4.5	3.6	4.3
Area 3	5.9	2.7	2.1	3.0	3.0	1.9	2.3	3.5	2.4	2.7	2.5	2.6	2.8	2.0	0.7	1.0
Area 4	14.8	14.3	11.9	17.2	20.8	10.1	12.9	16.1	15.5	12.4	14.8	13.5	5.9	7.4	7.3	3.5
Area 5	33.0	26.0	18.0	20.7	34.3	35.9	45.4	36.2	47.4	37.2	41.1	36.0	43.4	43.8	45.8	46.0
Area 6	24.5	34.4	37.9	29.1	14.5	24.5	13.3	15.2	8.8	24.1	24.2	22.3	22.8	25.1	24.3	34.4
Areas 1,2	0.7	0.7	0.6	0.5	0.6	0.6	1.2	0.7	0.3	0.1	0.3	1.1	0.3	0.0	0.1	0.4
Areas 1,3	0.3	0.1	0.3	0.1	0.1	0.6	0.9	0.3	0.0	0.1	0.3	0.1	0.3	0.0	0.0	0.0
Areas 2,4	0.5	0.6	0.6	0.4	0.9	0.6	1.2	1.8	1.2	0.6	0.2	1.1	0.8	0.8	0.6	0.6
Areas 3,4	1.4	0.6	1.2	0.7	0.7	0.7	0.7	0.8	0.5	0.2	0.2	0.4	0.4	0.3	0.1	0.4
Areas 1,2,3,4	1.3	0.8	0.2	0.6	0.2	0.3	0.4	0.1	0.3	0.1	0.0	0.3	0.1	0.1	0.0	0.0
Areas 3,5	0.7	0.2	0.2	0.3	0.2	0.4	0.7	0.3	1.0	0.4	0.0	0.5	0.1	0.0	0.1	0.0
Areas 4,5	2.0	1.7	1.4	2.1	3.1	2.2	4.0	2.9	0.9	1.5	0.2	2.9	2.3	2.1	2.7	1.2
Areas 3,4,5	1.0	0.2	0.1	0.1	0.2	0.5	0.9	0.2	0.0	0.2	0.0	0.2	0.1	0.1	0.0	0.4
Areas 5,6	4.8	3.6	4.4	7.9	3.9	5.6	3.8	3.7	0.5	1.3	0.2	3.5	4.5	5.0	4.8	2.5
Area 16(N. of BNP)	0.1	0.7	0.6	0.6	0.0	0.8	0.3	0.0	0.2	0.1	0.1	0.3	0.1	0.1	0.2	0.2
Area 17(S. of BNP)	1.1	4.2	6.5	4.8	4.8	5.2	2.0	4.1	6.6	7.7	4.3	4.6	8.9	6.1	7.0	3.1
Other	0.9	1.5	3.9	2.1	2.9	3.8	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Area 20								0.4	0.2	0.5	0.6	1.5	0.3	0.1	0.0	0.0
Area 21								0.2	0.3	0.3	0.6	0.3	0.1	0.6	0.1	0.0
Area 22								0.2	0.0	0.1	0.2	0.1	0.1	0.3	0.0	0.0
Area 23								0.1	0.2	0.5	0.3	1.1	0.6	0.4	2.0	1.6
Area 24								0.0	0.2	0.7	0.2	0.0	0.1	0.0	0.1	0.2

Average annual fish size and total trip landings were compared for common species landed by both angling and spearfishing. Mean annual fish weight was significantly greater from spearfishing trips for black grouper, red grouper, and gray snapper ($p < 0.01$, t-test), but not significantly different for hogfish, Nassau grouper, and mutton snapper ($p > 0.05$, Table 7). Mean annual landing per trip were significantly greater for spearfishing trips than for hook and line trips for black grouper, Nassau grouper, and red grouper ($p < 0.01$, t-test), while no significant differences were found for hogfish, gray snapper, or mutton snapper ($p > 0.05$, Table 7). Thus, although average gray snapper size was larger for spearfishing trips, there was no significant difference in weight per trip because anglers landed more fish per trip. In contrast, spearfishing landed significantly more Nassau grouper per trip than angling ($p > 0.01$). In summary, although spearfishing targeted some of the same species as anglers, the total landings from spearfishing was only a small portion of the total landings from hook and line fishing.

Comparison of Fishery-Dependent and Independent Trends

The SEFSC has conducted fishery-independent, visual sampling of fishes

Table 6.—Species landings composition by year for 3,473 recreational spearfishing fishing trips in BNP. Several taxa were reported only at the family level in 1976 and 1977.

	Scientific name	Common name	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	All years
1	*Acanthocybium solandri*	Wahoo		1															1
2	*Acanthurus bahianus*	Ocean surgeon						1	1										2
3	*Acanthurus coeruleus*	Blue tang												1					1
4	*Albula vulpes*	Bonefish		1															1
5	*Alectis ciliaris*	African pompano						1		1		1							3
6	*Anisotremus surinamensis*	Black margate			2	10	6	28	23	29	3	8	8	9	6	3	7	5	147
7	*Anisotremus virginicus*	Porkfish				1	2	4	6	1			3			1			18
8	*Archosargus probatocephalus*	Sheepshead		11	5														16
9	*Archosargus rhomboidalis*	Sea bream						4											4
10	*Aulostomus maculatus*	Trumpetfish							2										2
11	*Balistes capriscus*	Gray triggerfish					2	1	2						1				6
12	*Balistes vetula*	Queen triggerfish					1	2		1									4
13	*Bodianus rufus*	Spanish hogfish			1	2		1	3	3			2		3				15
14	*Calamus arctifrons*	Grass porgy								1									1
15	*Calamus bajonado*	Jolthead porgy	2	18	33	15	1	1	8	13		1	1				1	1	95
16	*Calamus calamus*	Saucereye porgy					4	1				5	1				1		12
17	*Cantherhines pullus*	Orangespotted filefish					1		1										2
18	*Canthidermis sufflamen*	Ocean triggerfish				6	1	7	1	4			3	3	2	1	4		32
19	*Caranx bartholomaei*	Yellow jack				3	10	39	42	18	2	6	7	11	6	3	17	11	175
20	*Caranx crysos*	Blue runner	9	2	4	12	6	9	2	8	1	2	4	2	3	1	1	1	67
21	*Caranx hippos*	Crevalle jack				2	3	2	9	4									20
22	*Caranx latus*	Horse-eye jack						1	1										2
23	*Caranx ruber*	Bar jack			1	4	2	8	5	1		2	1	4	4		1	1	34
24	*Caranx* spp.	Unidentified jack	7	53	45					12	1	1						1	120
25	*Carcharhinus* spp.	Unidentified shark	2	1		1			2			1			1				8
26	*Centropomus ensiferus*	Swordspine snook					1												1
27	*Centropomus undecimalis*	Common snook						1											1
28	*Chaetodiperus faber*	Atlantic spadefish				2	14	4	3	4	1	2	4		3				37
29	*Coryphaena hippurus*	Dolphin	1	1	8	1			6	7			1	5					30
30	*Dasyatis* spp.	Unidentified stingray				1		1											2
31	*Diplectrum formosum*	Sand perch					2												2
32	*Elagatis bipinnulata*	Rainbow runner					2	1		1									4
33	*Epinephelus adscensionis*	Rock hind			2	3	3	2	4	3			4					2	23
34	*Epinephelus cruentatus*	Graysby				5	9	9	9	7	1		1	1					42
35	*Epinephelus flavolimbatus*	Yellowedge grouper								8									8
36	*Epinephelus fulvus*	Coney				1			2										3
37	*Epinephelus guttatus*	Red hind			1	21	6	11	15	9	2	3			1				69
38	*Epinephelus inermis*	Marbled grouper								1									1
39	*Epinephelus itajara*	Jewfish				2		2	1	1									6
40	*Epinephelus morio*	Red grouper			7	135	76	181	128	200	15	38	12	11	22	14	7	5	851
41	*Epinephelus striatus*	Nassau grouper			14	310	187	158	82	29	3	10	5	2	2	3	3	1	809
42	*Gerres cinereus*	Yellowfin mojarra						1											1
43	*Ginglymostoma cirratum*	Nurse shark			2		2		1	3									8
44	*Gymnothorax* spp.	Unidentified moray				2	2	1											5
45	*Haemulon album*	Margate			7	14	16	5	14	6			5	2		1	3	2	75
46	*Haemulon carbonarium*	Caesar grunt					1					1		1	2		1	2	8
47	*Haemulon flavolineatum*	French grunt				2			3										5
48	*Haemulon macrostomum*	Spanish grunt				1	1	1	5	4	1	1	2			1	2	1	20
49	*Haemulon parrai*	Sailor's choice						3						1			1		5
50	*Haemulon plumieri*	White grunt	1		7	47	22	24	32	86		13	16	10	19	1	2	29	309
51	*Haemulon sciurus*	Bluestriped grunt	1		14	34	47	32	25	26	2		9		5	6		1	202
52	*Haemulon* spp.	Unidentified grunt	69	108	41	1	20		1	36		1						0	277
53	*Haemulon striatum*	Striped grunt					1												1
54	*Halichoeres bivittatus*	Slippery dick											11						11
55	*Halichoeres radiatus*	Puddingwife								1									1
56	*Halichoeres* spp.	Unidentified wrasse								1									1
57	*Holacanthus ciliaris*	Queen angelfish								2									2
58	*Holocentrus adscensionis*	Squirrelfish												1					1
59	*Kyphosus incisor*	Yellow chub								1				1				1	3
60	*Kyphosus sectatrix*	Bermuda chub				2	5	9	3	4	2	2		1				2	30
61	*Kyphosus* spp.	Unidentified chub												1			2		3
62	*Lachnolaimus maximus*	Hogfish	452	1,562	1,704	1,334	1,068	1,660	1,661	2,022	127	353	284	237	199	216	304	103	13,286
63	*Lactophrys* spp.	Unidentified boxfish					1	1		2									4
64	*Lagodon rhomboides*	Pinfish								3									3
65	*Lutjanus analis*	Mutton snapper			1	69	57	63	58	52	3	11	7	3	5	15	12	8	364
66	*Lutjanus apodus*	Schoolmaster				26	13	45	70	50	2	2	9	11	7	3	8	6	252
67	*Lutjanus buccanella*	Blackfin snapper								1									1
68	*Lutjanus cyanopterus*	Cubera snapper				11		3	1								1		16
69	*Lutjanus griseus*	Gray snapper	3		26	206	182	309	248	201	15	74	43	13	34	11	52	15	1,432
70	*Lutjanus jocu*	Dog snapper				8	14	24	7	4	1	2			1	1	1		63
71	*Lutjanus mahogoni*	Mahogany snapper					1	1	1	1			1	3		1		1	10
72	*Lutjanus* spp.	Unidentifed snapper	128	306	251		5	2	14	1		2				2	7		718
73	*Lutjanus synagris*	Lane snapper				4	2	2	5	6				1	1				21
74	*Lutjanus vivanus*	Silk snapper							3										3
75	*Malacanthus plumieri*	Sand tilefish						1	1										2
76	*Mulloidichthys martinicus*	Yellow goatfish						2								1		1	4
77	*Mycteroperca bonaci*	Black grouper			10	219	80	223	97	69	12	14	5	6	7	10	8	5	765
78	*Mycteroperca interstitialis*	Yellowmouth grouper			1	2	1	6		2					2				14

continued

Table 6.—(Continued).

	Scientific name	Common name	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	All years
79	*Mycteroperca microlepis*	Gag			8	8	3	15	24	8	1	4	1	3	1		1		77
80	*Mycteroperca phenax*	Scamp				2	1		3										6
81	*Mycteroperca venenosa*	Yellowfin grouper			4	7	4	1	14										30
82	*Ocyurus chrysurus*	Yellowtail snapper				12	35	7	34	16		22	3	5	29	10	5		178
83	*Panulirus argus*	Caribbean spiny lobster	24	354	411	432	25	190	803	182	35	132	27	7			1		2,623
84	*Panulirus guttatus*	Spotted lobster			1	3		1	5										10
85	*Pomacanthus arcuatus*	Gray angelfish								2									2
86	*Priacanthus arenatus*	Bigeye		9	29		1		1					1					41
87	*Prionotus* spp.	Unidentified searobin							1										1
88	*Rhomboplites aurorubens*	Vermilion snapper							11										11
89	*Sarda sarda*	Atlantic bonito		1	1														2
90	*Scarus guacamaia*	Rainbow parrotfish					1			1						1		2	5
91	*Scomberomorus cavalla*	King mackerel								1						1			2
92	*Scomberomorus maculatus*	Spanish mackerel			1	3	1	7	6	2			1						21
93	*Scomberomorus regalis*	Cero mackerel				10	8	4	16	7			1	1	2	1	1	2	53
94	*Scyllarides aequinoctialis*	Shovel-nosed lobster						1								12			13
95	*Seriola dumerili*	Greater amberjack			1	31	9	3	4	3	1	1	5	1					59
96	*Sphoeroides* spp.	Unidentified puffer					1												1
97	*Sphyraena barracuda*	Great barracuda	9	17	10	11	9	16	27	31	1	4	1	6	3		14	2	161
98	*Sphyrna tiburo*	Bonnethead								1									1
99	*Strombus gigas*	Queen conch	5	127	137	203	61	105	204	129	27	20							1,018
100	*Thunnus* spp.	Unidentified tuna	1	3	8					1		1							14
101	*Trachinotus falcatus*	Permit						3	3	2	1		1		3		3		16
102	*Tylosurus crocodilus*	Houndfish															5		5
103	N.A.	Unidentified bigeye								1									1
104	N.A.	Unidentifed filefish								1									1
105	N.A.	Unidentifed catfish			1														1
106	N.A.	Unidentified grouper	201	665	738	0	3	24	5	161	3	10	1	1		0			1,812
107	N.A.	Unidentified anglefish				4	7	2	16						4				33
108	N.A.	Unidentified lefteye flounder								3	1								4
109	N.A.	Unidentified fishes	16	76	34		1	4	2	6									139
110	N.A.	Unidentified parrotfish			2	1	10	26	10	8	2	1	2		2	7			71
Totals			931	3,316	3,573	3,246	2,060	3,307	3,797	3,516	266	751	492	366	380	327	476	211	27,015
No. of interviews			127	385	463	409	336	381	491	362	38	106	94	68	61	54	61	37	3,473
Avg. landed/trip			7.33	8.61	7.72	7.94	6.13	8.68	7.73	9.71	7.00	7.08	5.23	5.38	6.23	6.06	7.80	5.70	7.78

Table 7.—Comparison of mean annual fish weight and mean total trip landings for six species from spearfishing and hook & line trips from 1978–1991 (* = $p < 0.05$, ** = $p < 0.01$, t-test, $n = 14$).

Species	Spearfishing trips Mean (range)	Hook and line trips Mean (range)
Hogfish		
Kg/fish	0.83 (0.57–1.10)	0.77 (0.60–1.00)
Kg/trip	3.04 (1.77–4.58)	0.08 (0.02–0.14)
Black grouper		
Kg/fish**	3.83 (1.95–5.94)	2.15 (1.10–4.88)
Kg/trip**	0.71 (0.13–1.78)	0.05 (0.02–0.12)
Nassau grouper		
Kg/fish	1.85 (0.07–4.65)	1.37 (0.74–2.60)
Kg/trip	0.28 (0.00–1.23)	0.08 (0.00–0.11)
Red grouper		
Kg/fish**	1.38 (0.91–2.31)	1.00 (0.68–1.21)
Kg/trip**	0.35 (0.02–0.61)	0.08 (0.02–0.19)
Mutton snapper		
Kg/fish	1.32 (0.76–1.99)	1.09 (0.58–1.85)
Kg/trip	0.16 (0.00–0.31)	0.12 (0.02–0.19)
Gray snapper		
Kg/fish**	0.64 (0.43–1.06)	0.27 (0.23–0.40)
Kg/trip	0.31 (0.03–0.57)	0.28 (0.02–0.49)

on inshore patch reefs and offshore bank reefs in BNP statistical Areas 5 and 23 (Fig. 1) since July 1988. Ault et al. (1998) showed that underwater visual size estimates of fishes corresponded well to sizes in headboat landings in the Florida Keys. Abundance indexes for the 10 most commonly landed fishes were compared between BNP creel census data (mean landings per trip) and SEFSC visual census data (mean abundance per sample) for combined statistical Areas 5 and 23 for July 1988–July 1991 (Fig. 9). Trends in the two indexes were highly similar for white grunt and great barracuda and somewhat similar for seven of the remaining fishes. The blue runner, *Caranx crysos*, exhibited the greatest difference, most likely because it was caught in many habitats while visual data were restricted to reefs. Despite having only 4 years of corresponding data (July 1988–July 1991), the two indices showed good correspondence between fishery-independent visual sample abundance and fishery-dependent creel sample abundance for reef fishes. A longer data time-series is needed, however, to identify meaningful trends in the relationship between recreational harvest and visual sample abundances.

Annual Mean Landings Rates

Annual mean catch (CPUE) and landings (LPUE) rates for eight commonly landed fishes were calculated in terms of fish per angler-hour for anglers (Fig. 10). Although variable, the annual rate trends for these eight species indicated a slight decreasing trend. The difference between CPUE and LPUE is the estimated bycatch. Dolphin and jolthead porgy had low release rates while grunts had the highest release rates. The divergence between CPUE and LPUE beginning in 1985 and 1990 for gray snapper, yellowtail snapper, and other snappers is most likely the result of increased releases as the result of new minimum size requirements discussed earlier.

Landings trends were further analyzed for species having 12 or more years of reported data on the basis of total number of fish landed per 100 trips (Table 8, Fig. 11). Trend curves were fitted to the data using linear, logarithmic, or exponential curves, as appropriate. Data from 1976 to 1978 were dropped from plotted trends for some species (Fig. 11) because it was clear that these data had been combined at the family level. Overall, the number

of fish landed per trip declined (Fig. 11), although landings declined more rapidly for some species than others. Landings declines for jolthead porgy and Nassau grouper were especially sharp. Size limits for gray snapper and yellowtail snapper established in 1985, probably accounted for reduced landings for those species.

Discussion

The Biscayne National Park recreational creel survey provides valuable data for monitoring marine resource trends and for better understanding impacts of recreational fishing on marine resources. Recreational fishing in BNP is intense because of its unique location near the large urban area of Miami. This study provides one of the most detailed examinations of recreational fishing in such a subtropical marine environment. Creel data show landings of over 170 species from a variety of habitats and are especially representative of weekend recreational fishing since 91% of the samples were collected on weekends. The data potentially have some bias because sampling was nonrandomly distributed over space and time. The validity of extrapolating results to weekday fishing is uncertain because of low sample coverage during weekdays. The relative contribution of recreational lobster fishing to total interviews is probably inflated because of concentrated sampling during opening days of the spiny lobster fishing season and 2 day sport season. The fact that sampling was highly concentrated at two access sites within BNP suggests that the data might not reflect use from other locations. Presumably, fishermen landing in BNP are aware that they have a high chance of being checked by park personnel and may be more conscientious of observing fishing regulations.

The classification of angler and diving party types provides some insights into recreational fishing. The fishing party type showing a high level of species preference was spiny lobster divers (89% of parties, Table 2). The remaining party classifications showed no preference or very generalized species preferences. Angling party classifications broadly overlapped in terms

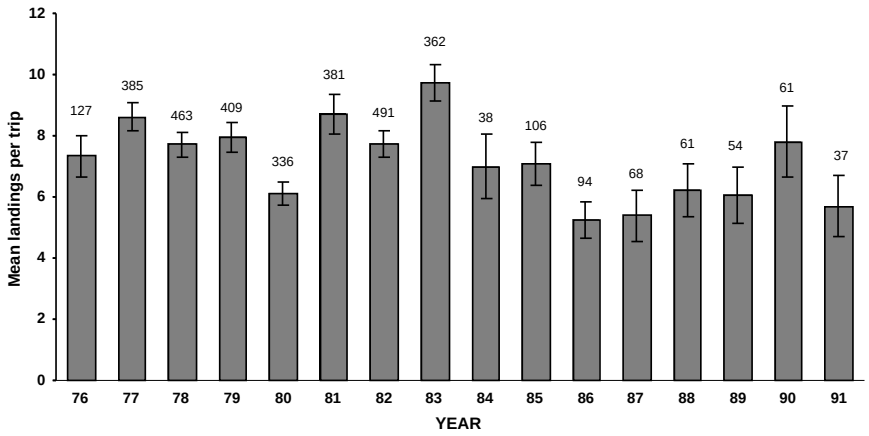

Figure 6.—Annual mean number of fish landed per spearfishing trip (± SE). Numbers show sample size.

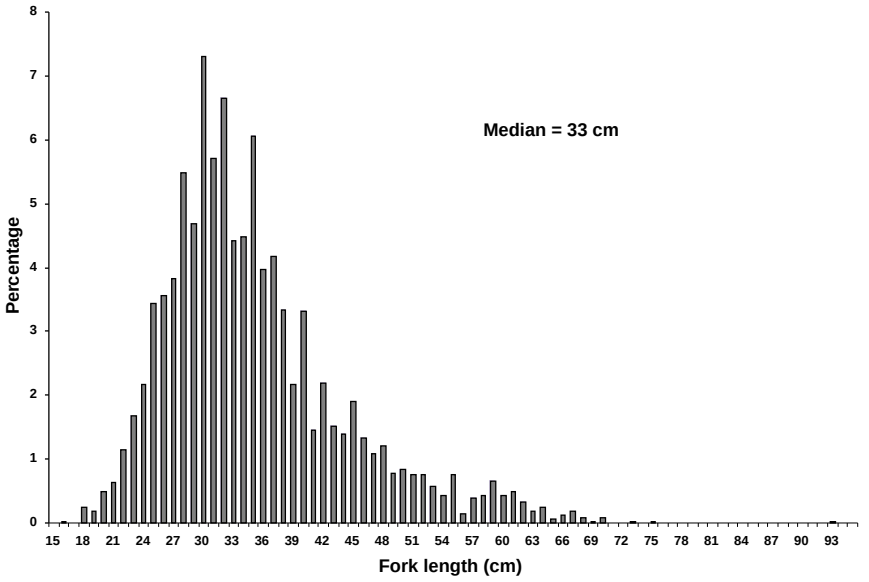

Figure 7.—Length-frequency distribution of speared hogfish sampled in creel surveys (mean = 35.06 cm FL, *n* = 3,323).

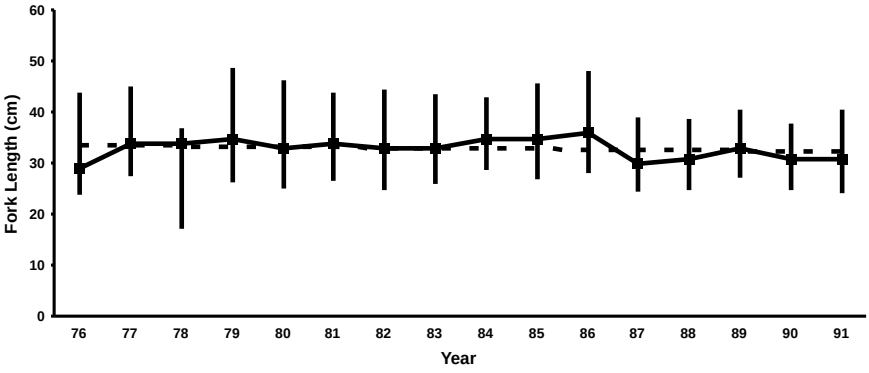

Figure 8.—Annual sizes of *Lachnolaimus maximus* landed from spearfishing trips. The solid line shows median sizes, vertical lines show ± SE around central means, and the dotted line shows the linear trend.

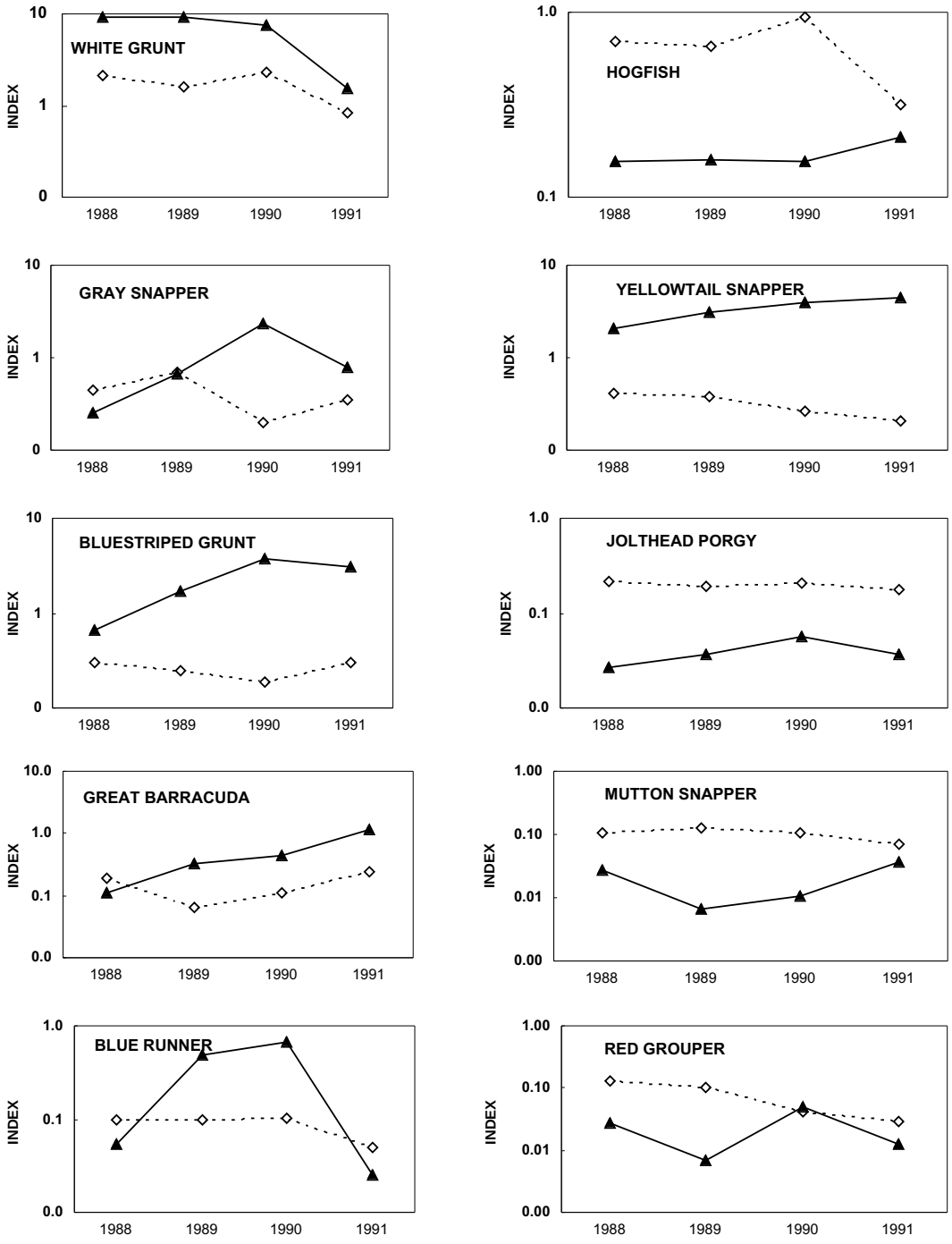

Figure 9.—Comparison of trends in annual mean abundance of landings per trip (diamonds, BNP Creel Census interviews) and mean observed abundance (triangles, SEFSC visual census samples) for the ten most commonly landed fishes from statistical areas 5 and 23 from July 1988 through July 1991.

of species landed and were not highly differentiated by levels of experience or emphasis on recreation or catching food. Only five taxa accounted for more that 50% of landings: white grunt, spiny lobster, gray snapper, unidentified grunts, and dolphin. Angling parties primarily interested in catching food accounted for about 20% of trip interviews and had about twice the landing per trip (mean = 19.5) than skilled recreational anglers (9.6), lob-

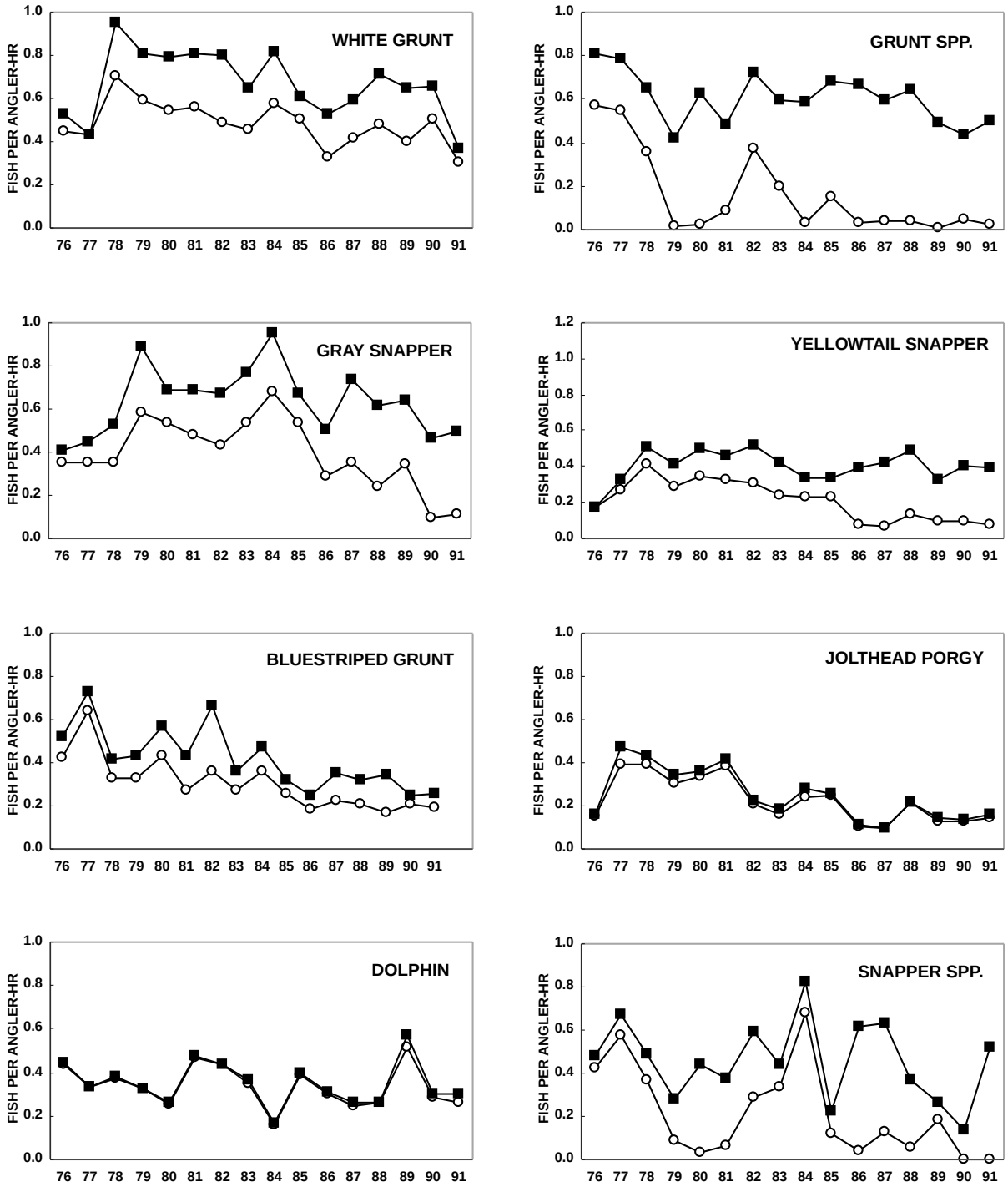

Figure 10.—Comparison of mean annual landing rates (circles) and catch rates (squares) reported in Biscayne National Park creel census interviews.

ster divers (8.2) and spearfishermen (7.8). Skilled parties, however, accounted for the greatest percentage (34%) of the total fishing trips.

Spearfishing data were closely examined because few quantitative studies exist and spearfishing is a frequent topic of management and angler concern due to its selectivity (Murdock, 1957; Long, 1957). Spearfishing was a small component of the overall recreational fishery. It accounted for 12.0%

Table 8.—Annual CPUE index (no. landed/100 interviews) by species with 12 or more years of data. Underline shows data for species after minimum size limits were implemented. Data for some species were available only at the family level in 1976 and 1977.

Species	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
African pompano			0.031	0.198	0.038	0.042	0.195	0.133	0.345	0.594	0.403		0.141		0.241	1.174
Atlantic bonito	5.000	2.651	2.265	1.256	0.798	2.020	0.781	0.433		0.297	1.610			0.425		0.587
Ballyhoo	0.789	1.363	0.944	3.802	13.835	15.320	31.809	14.481	7.759	4.900	3.382	1.644		1.558		
Bar jack	0.197	0.076	0.220	0.264	0.342	1.641	0.753	0.666	0.172	0.520	0.644	0.774	0.986	0.142	0.602	0.196
Bermuda chub			0.157	1.620	4.257	2.315	2.565	2.130	2.241	1.633	1.369	1.547			0.602	1.370
Bigeye	3.421	9.353	6.889	0.529	1.862	3.367	0.753	0.233		0.445	0.725	4.642	0.282	0.142	0.361	0.196
Black grouper	0.132		1.101	11.901	6.727	12.668	6.189	4.028	6.207	4.677	1.691	2.418	2.394	4.108	1.566	1.370
Black margate			0.063	0.694	0.456	1.599	0.976	1.032	0.690	1.782	1.127	1.257	2.958	1.133	2.530	2.153
Bluerunner	8.618	4.354	3.555	7.537	11.631	17.340	18.233	22.204	7.931	12.027	23.752	27.369	25.211	16.997	14.337	8.415
Bluestriped grunt	29.276	3.900	24.190	50.182	47.777	35.269	67.076	38.349	53.276	30.809	20.290	37.814	37.183	27.620	29.398	26.223
Cero mackerel			0.252	6.512	6.613	6.987	5.074	3.628	2.931	2.153	4.187	6.867	3.662	1.558	3.133	1.174
Crevalle jack				3.537	0.988	0.463	3.541	2.297	0.172	0.223	0.403	1.354	1.690	0.425	0.482	
Dolphin	113.224	53.692	57.314	54.612	26.416	76.010	68.637	57.490	7.241	63.697	55.153	30.754	43.803	128.187	55.060	89.041
Gag	0.132		0.692	4.066	1.710	1.978	4.572	3.129	2.414	1.039	0.644	2.031	1.831	0.425	0.361	2.153
Gray snapper	2.566		7.644	145.025	151.957	150.589	114.943	169.740	196.034	138.976	61.514	88.878	58.310	100.567	29.277	31.703
Gray triggerfish				0.264	1.064	0.421	3.318	2.397	1.207	1.114	0.242	1.547	2.113	0.850	0.843	3.327
Graysby			0.283	1.587	2.889	4.251	2.816	2.830	1.379	3.489	1.369	2.805	7.465	3.116	7.108	1.370
Great barracuda	30.921	19.614	15.697	25.587	27.708	14.731	22.693	17.144	11.724	14.180	19.726	23.694	27.324	11.331	19.639	19.765
Greater amberjack			0.063	2.182	1.596	2.146	1.394	0.566	0.172	0.520	0.966	1.547	0.141	0.850	0.120	1.566
Grouper spp.	73.684	88.792	64.360	1.785	0.304	2.399	1.589	15.413	3.448	5.419	0.483	0.967	2.394			
Grunt spp.	257.105	254.714	139.352	2.876	6.575	12.710	15.054	73.136	6.724	21.381	3.623	8.801	4.648	1.841	19.518	2.153
Hogfish	44.145	67.134	62.535	48.661	48.727	84.596	49.596	76.498	36.897	38.827	31.723	29.691	38.169	36.686	48.554	23.092
Jack spp.	8.618	14.464	10.506	0.298	0.076	1.641	0.502	1.764	0.517	1.707	0.242	0.774				0.196
Jolthead porgy	13.816	50.322	77.477	62.744	46.636	38.805	22.693	20.406	36.724	30.586	4.911	7.544	18.732	13.881	15.904	13.894
King mackerel			0.157	1.421	1.026	1.178	0.836	1.032	0.517	0.891	0.403	1.257	0.563	0.850	2.169	0.783
Lane snapper			1.919	5.653	14.785	9.428	6.802	6.059	1.034	6.013	2.174	5.513	11.127	3.824	1.205	0.783
Margate			0.535	2.017	1.900	1.641	5.018	1.431	0.517	1.633	3.623	2.998	0.845	1.133	2.410	0.391
Mutton snapper			1.258	16.331	16.268	14.689	9.256	13.316	14.138	5.568	6.924	23.114	11.127	11.331	10.723	6.654
Nassau grouper	0.461		0.912	17.719	15.317	9.470	6.050	2.130	2.759	3.935	1.208	1.161	1.831	1.983	0.602	0.196
Nurse shark			0.063	0.231	0.152	0.210	0.195	0.566	0.345	0.074		0.387	0.141	0.283		0.391
Ocean triggerfsh			0.283	4.595	5.549	4.503	0.335	2.430	0.517	2.821	2.738	2.031	5.211	2.408	4.096	0.587
Parrotfish spp.			0.377	0.694	0.988	1.473	1.645	2.097	0.690	0.520	0.966	1.644	2.113	2.266	0.120	
Pinfish	0.132		3.209	17.157	18.092	12.037	19.849	30.260	8.448	2.598	7.407	6.963	1.690	5.382	1.325	
Porkfish				0.463	1.862	1.726	0.613	2.097	0.345	0.520	0.644	1.354	0.423	0.992	1.566	0.783
Queen triggerfsh			0.031	0.364	0.532	0.758	0.251	0.399		0.668	0.081	0.677	0.141	0.992	0.964	0.783
Red grouper	0.461		1.730	18.876	10.718	19.192	9.060	22.437	15.172	16.110	4.348	8.414	9.577	10.765	3.494	2.935
Red hind			0.440	4.826	2.433	3.030	5.185	1.132	2.414	1.188	0.644	1.161	2.676	0.567	0.361	6.849
Rock hind			0.252	1.554	0.608	0.631	2.147	0.699		0.891	0.403	0.097	0.704	0.850	0.361	0.391
Sailfish	0.526	0.227	0.472	0.231	0.076	0.210	0.167	0.300		0.371	0.242	0.193	0.141	0.142	0.120	0.783
Sailors choice			0.975	2.215	2.585	1.768	1.756	3.262	1.552	1.188	1.771	4.836	17.042	8.215	3.133	2.935
Sand perch	5.658	3.218	15.351	9.289	8.894	6.818	2.844	2.264	11.897	0.520	2.335	2.418	2.113	0.850	0.843	0.783
Sand tilefish			0.031	1.124	1.558	1.305	1.728	0.599		0.371	0.081	0.774	0.845	0.567	0.241	
Saucereye porgy				0.033	7.678	23.106	2.063	2.430	0.517	11.359	4.911	1.934	1.268	2.408	6.386	0.196
Schoolmaster			0.755	2.380	3.801	4.293	3.513	3.296	0.862	2.004	2.254	5.513	4.507	7.224	3.614	2.935
Seatrout	0.658	4.354	9.059	4.132	4.485	1.473	13.633	7.956	6.897	1.633	0.644	0.580	0.141	1.133		
Shark spp.	1.579	0.492	0.535	0.198	0.190	0.295	0.223	0.033		0.297		0.387	0.423	0.142	0.120	
Snapper spp.	195.000	242.030	157.156	1.223	1.558	1.726	2.648	4.860	10.000	4.974	0.483	3.095	0.704	1.133	0.843	
Spadefish				0.066	0.532	0.210	0.139	0.233	0.172	0.148	0.322	0.097	0.986		0.120	0.391
Spanish grunt				0.099	0.076	0.800	0.446	0.533	0.172	0.148	0.242	0.290	0.704	0.283	0.241	0.196
Spanish mackerel			0.315	0.992	0.760	1.263	3.122	0.466	0.172	0.297	4.267	1.257	0.141	0.142	0.120	1.370
Spiny lobster	79.737	111.056	80.466	73.190	114.253	76.389	97.909	44.041	131.552	37.416	113.768	113.636	155.915	170.538	233.494	203.718
Wahoo	0.263	0.530	0.252	0.793	0.532	0.547	0.502	0.566	0.517	0.223	0.886	0.580	1.268	0.283	0.723	1.957
White grunt	36.842	2.272	71.186	221.521	205.853	224.747	208.754	129.561	137.241	171.641	106.522	137.524	161.127	129.320	166.506	69.667
Yellow jack			0.031	0.298	0.950	4.798	2.258	2.264	1.034	1.707	1.530	4.642	5.352	2.691	5.542	3.914
Yellowtail snapper	0.329		10.727	71.273	94.033	80.724	83.301	77.164	62.586	58.203	14.010	17.118	34.789	25.637	25.542	18.004

of all recreational fishing trip interviews, 10.3% of the total number of landings, but only 7.6% of the total number of organisms caught in BNP. No data exist, however, to assess cryptic mortality of speared organisms that escape capture. The fact that fishing trips were randomly selected for interviews suggests that the relative proportion of angler to spearfishing trips is valid.

Spearfishing was highly selective for hogfish which accounted for almost half (49%) of spearfishing landings. The data suggest, however, that there is relatively little competition for hogfish between anglers and spearfishermen. Anglers rarely mentioned hogfish as preferred target species (Table 2). Many anglers consider hogfish difficult to hook and only 15.7% of hogfish were landed by angling. After hogfish, spearfishing most commonly targeted various grouper and snapper. While the average size of some species of fish caught by spearfishing was larger than that caught by angling (e.g. gray snapper, red grouper, black grouper), there was no significant size difference for other species (e.g. white grunt, hogfish, Nassau grouper). Even though spearfishing landed larger fish for some species, anglers tended to land more fish because they made more trips.

Spearfishing can cause behavioral changes and other impacts that were not addressed by this study. Some species, for example, are known to avoid divers and areas where spearfishing is practiced (Randall, 1982). This avoidance can impact recreational diving, education, tourism, and other nonextrac-

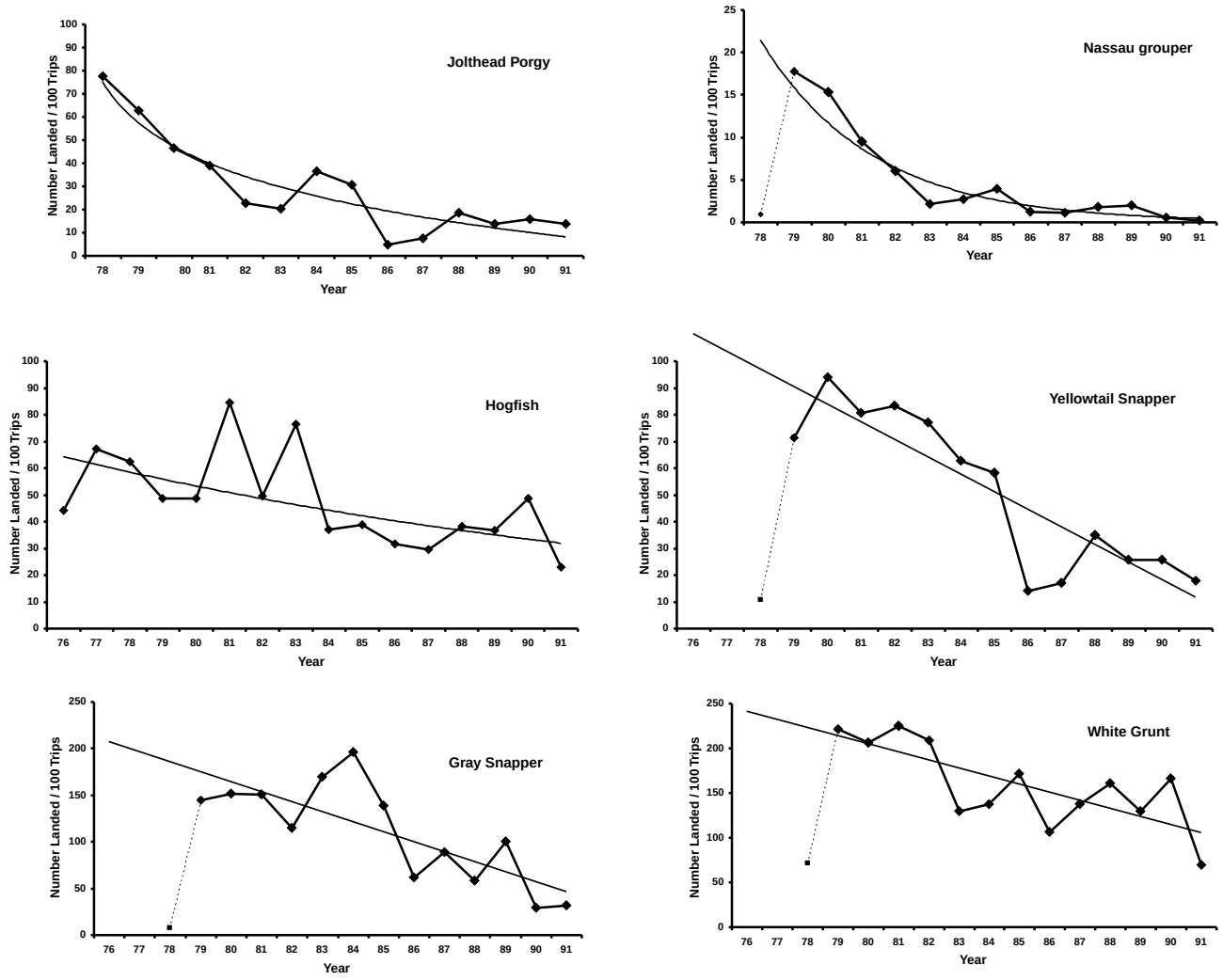

Figure 11.—Trends in total number of fish landed per 100 trips from BNP interviews. Fitted curves were linear for yellowtail snapper, gray snapper, and white grunt; exponential for hogfish and Nassau grouper; and logarithmic for jolthead porgy. Data for some species were excluded from analysis for 1976–78 because they were reported at the family level.

tive uses. Simply moving fish around is not a fishery problem, however, unless fish populations are excluded from essential habitat for foraging, shelter, or reproduction (Bohnsack, 1982).

Unlike earlier studies of BNP (Tilmant et al., 1979; Tilmant, 1981; Tilmant and Stone[1]), this study showed declining CPUE for some species. The continuous CPUE decline of jolthead porgy, for example, suggests that it may be particularly vulnerable to increased exploitation. Whether the observed landings declines represent diminished resources or diminished shares caused by increased usage cannot be precisely determined from available data without some measure of total effort. Over the study time period, the estimated population of Miami-Dade County increased 32.3% from 1,482,300 in 1976 to 1,961,700 in 1991 (Floyd, 1997). An assumption that recreational fishing effort is directly proportional to the total population would suggest that total recreational fishing effort also increased by 32%.

Although observed drops in mean annual number of fish landed per angler trip in 1985–86 and in 1990–91 were most likely the short-term result of numerous new minimum size limits enacted in Florida in 1985 and 1990, respectively, the long-term impacts of these conservation efforts could not be assessed because of disruptions to fishing and the environment caused by Hurricane Andrew. More recent regulations such as new minimum size and bag limits also are likely to impact recreational fishing in Biscayne National Park. The recreational creel survey has obvious importance for resource monitoring and would be enhanced if data can be collected on total fishing effort.

Acknowledgments

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